GIANT GAP WATER SUPPLY

PROPOSED FOR

CITY AND COUNTY OF SAN FRANCISCO

GIANT GAP WATER SUPPLY

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City and County of San Francisco, Cal.

ENGINEERS' CAMP AT GIANT GAP, PLACER COUNTY

From North Fork of American River, Placer County, California

— BY —

RUSSELL L. DUNN

— AND —

WILLIAM C. ALBERGER

Proposition to Board of Supervisors,

FEBRUARY, 1901.

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BRIEF STATEMENT OF PROPOSITION OFFERED.

The City of San Francisco is herein offered a source from which it may obtain a water supply, pure in quality, and sufficient in quantity to provide for a population of 1,000,000.

The City of San Francisco is offered a plan of works, which will satisfy every engineering requirement of safety, imperishability, minimum of cost of first construction, minimum of operative cost, and of design provision for extensions made at the sole cost of the savings from the increased consumption they provide for.

The City is offered, as a valuable appurtenance to the source of supply and the plan of works, a great water power from the downward fall of the water on its flow to the City. With this, the City can operate its water distribution works, light its streets and parks, heat its schoolhouses, cook for the hospitals and jails, provide for every public utility requiring fuel, power or light, and there will still be 8,000 horse power, which, sold at less than the cost of production from fuel, will give to the City a net annual income of over $1,000,000.

We are willing to convey to the City the water rights to the flowing water, the fee to certain lands, and to contract to construct, (1) the complete water supply works and City distribution, prepared to deliver 45,000,000 gallons daily, and (2) the complete water power and transmission works delivering 13,000 24-hour horse power in the City, on the general plan offered, with allowance for different constructive details and costs of rights-of-way, at a price which will not exceed $17,350,000. Or,

We are willing to convey to the City the water rights and fee as above, and the right to the manufacture and use solely by and for the City for this special purpose of the submerged conduit, for the sum of $2,000,000. And

The City with these, and using the economical advantages it possesses, can itself make the construction of the works above enumerated on the offered plan unmodified for $14,000,000.

The City is therefore not only offered the pure water and plentiful water for which it has asked but cheap water as well, and associated with it cheap light for the streets, cheap heat and cheap power for all public utilities, and a possible income so large as to make the water, light and heat costless.

Russell L. Dunn

Wm. C. Alberger

VIEW LOOKING WEST THROUGH GIANT GAP.
Grade Line Giant Gap Canal in foreground.

VIEW LOOKING TOWARD EUCHRE BAR FROM GIANT GAP.
Grade Line of Giant Gap Canal. Mountains of watershed in background.


MAP
GIANT GAP WATER SUPPLY
North Fork of American River
Proposed For The
CITY of SAN FRANCISCO
Scale 10 Miles to 1 Inch
SAN FRANCISCO BAY
SAN FRANCISCO
OAKLAND
BERKELEY
SAN PABLO BAY
SUISUN BAY
SUISUN
FAIRFIELD
DAVISVILLE
DIXON
BATAVIA
ELMIRA
DENVERTON
BENICIA
BENICIA TUNNEL
STEEL PIPE
61.5" dia.
TULE
111 Miles
SACRAMENTO
SACRAMENTO RIVER
STEAMBOAT SLOUGH
AMERICAN RIVER
SOUTH FORK
MIDDLE FORK
ARCADE
ANTELOPE
ROSEVILLE
ROCKLIN
LOOMIS
PENRYN
NEWCASTLE
AUBURN
STEEL PIPE
82" dia.
CLIPPER GAP
APPLEGATE
LANDER
COLFAX
GOLD RUN
DUTCH FLAT
TOWLE
BLUE CANYON
EMIGRANT GAP
CANADA FORK
NORTH FORK
CISCO
WATERSHED

To the Honorable Board of Supervisors,
City and County of San Francisco,

GENTLEMEN:—

The undersigned, in line with the third sub-division of your Resolution No. 257; of date March 26th, 1900, beg leave to submit a description of a source of water supply hereby proposed for the City of San Francisco, and with it an explanation of a system of works that is suggested for its utilization. In conclusion we submit a preliminary proposition to make the construction of the suggested system of works, under contract to sell them to the City together with the rights to the source of supply described.

We have assumed the suggestion of your Resolution No. 257, for a supply two or three times the present consumption of water in the City, to refer particularly to the source of supply, which you desired to obtain ample and sufficient, not alone for the City's present necessities, but to provide in anticipation for its future necessities as well. So far as the means for making the source available were inferred, we have assumed, that it was your intention to provide the least costly means by which the present necessities of the City could be satisfied, and with which you could promise to the City in the future, that there should be no greater charge for its added requirement of service than the City of to-day will willingly accept to bear.

In explanation of our submission of a description of a system of works, your attention is respectfully invited to their general plan, and some of the constructions proposed. These make possible the low contract figures offered herein, and are, we believe, new, in that they have not heretofore been suggested or formally considered in connection with the utilization of a source of water supply for the City.

SOURCE OF GIANT GAP WATER SUPPLY.

The source of water supply proposed is the North Fork of the American River in Placer County, diverted into the head of the works at Euchre Bar, two miles up stream from Giant Gap, and five miles east of the town of Dutch Flat on the Central Pacific Railroad. By rail from San Francisco, Euchre Bar is distant 165 miles.

The watershed furnishing the supply is the portion of the Sierra Nevada Mountains adjacent to the railroad on its south side between Shady Run and Summit Stations. Its area is 212 square miles, all mountainous. Elevations range from 1,900 feet to 9,000 feet, more than nine-tenths of the area being over 4,000 feet above the sea level. The exposed rock formations are slates, granite and volcanic rocks. The surface is very generally covered with soil and vegetation, but comparatively little of the latter is merchantable timber.

RAIN AND SNOWFALL ON THE WATERSHED.

On this watershed the precipitation is largely snow, which accumulates in winter on the elevations over 4,000 feet, and melting during the dry season maintains a high stage of the river flow until late in the summer. The flow of years of average precipitation, past Euchre Bar on August 1st, is over 100,000,000 gallons. The lowest stage of flow is in September and October. In the driest years this flow does not decrease below 30,000,000 gallons daily, and by November 15th, the autumn rains will have again increased the flow to a volume in excess of 100,000,000 gallons.

The actual flow of the River then between November 15th and August 1st, 8½ months, exceeds 100,000,000 gallons daily; between August 1st and November 15th, 3½ months, the flow is less than 100,000,000 gallons daily, the extreme minimum being 30,000,000 gallons.*

It is proposed to restore the flow of the low water stages to the extent of the City's requirements from storage reservoirs to be constructed in the drainage basin.† The aggregate available storage capacity is between 37,500,000,000 and 40,000,000,000 gallons and the catchment areas are sufficient to provide the water for storage from the annual precipitation, with the exception of the Ice Lakes Reservoir which from its own drainage basin would store in seasons of average rainfall 3,000,000,000 gallons. In addition there are

*Municipal Report, San Francisco 1876-77, Water Supplies, p. 709, 4th par.

†Mun. Rep. S. F. 1876 77, p. 714, 3rd par.

reservoir storage areas outside of but but adjacent to the watershed proposed which can be utilized as part of the proposed source. The storage possibilities of our proposed source are indisputably sufficient for any possible requirement of the City for the next century, and are at the same time sufficient to provide the requirement independent of the low water flow of the river.

RESERVOIR SITES.

Name	Height of Dam	Material of Dam	Storage Capacity
1. Palisade Lake	70	Granite Masonry	3,400,000,000 Gallons
2. Ice Lakes	100	Granite Masonry	26,000,000,000 "
3. Lake Valley	75	Earth	3,800,000,000 "
4. Six Mile Valley	60	Earth	800,000,000 "
5. Two Mile Valley	65	Earth	2,000,000,000 "
6. Onion Valley	(not surveyed)	Est. over	500,000,000 "
7. Soda Springs Valley	(" ")	" "	1,000,000,000 "
8. Big Valley	(" ")	" "	1,000,000,000 "
9. Small Lakes	(" ")	" "	500 000,000 "
			39,000,000,000 Gallons

The first six of the above are within two miles of the railroad, and are accessible by wagon roads (some would require repair) from Emigrant Gap and Soda Springs Stations.

The seasonal (July 1st to July 1st) precipitation in the watershed is always large. The following tabled figures are from Reports of the U. S. Weather Bureau. Emigrant Gap is in the watershed. Cisco, Summit and Towles are just outside of it. (See Maps.)**

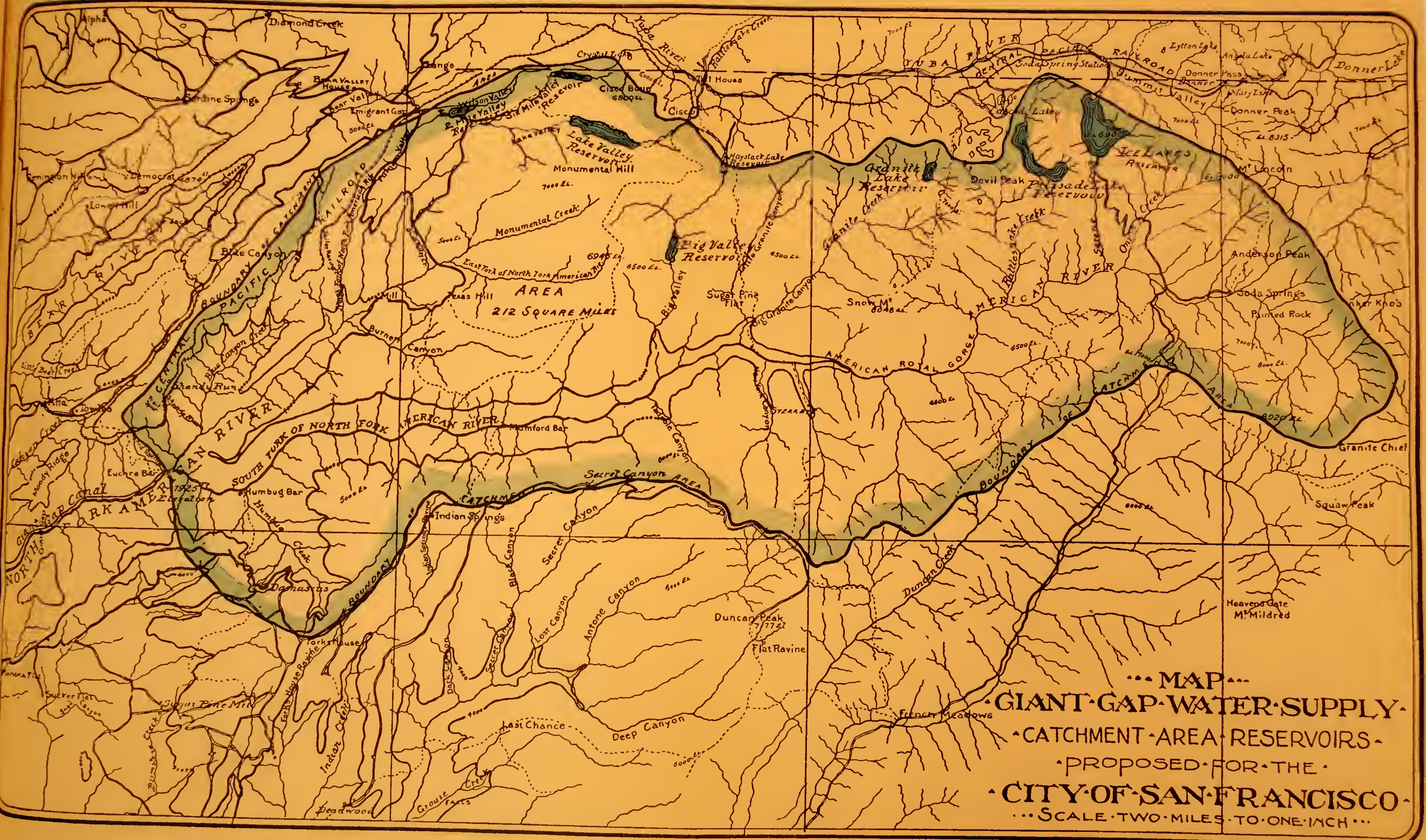
TABLE I.

U. S. Weather Bureau Record of Precipitation at the following named Stations. (Snow reduced to water at 10 to 1.)

Year	Cisco	Emigrant Gap	Summit	Towles
1879–80	51 59	75 11	86 30	
1880–81	78 34	59 82	22 65*	
1881–82	69 95	57 50	55 35	
1882–83	41 20	39 43	40 69	
1883–84	55 09	58 57	52 29	
1884–85	39 75	45 19	22 39*	
1885–86	55 92	68 38	47 10	
1886–87	41 50	44 62	47 25	
1887–88	34 02	48 01	38 27	
1888–89	38 60	46 19	32 89	
1889–90	97 63	86 49	75 85	
1890–91	17 79		21 08*	42 75
1891–92	43 26		* *	55 77
1892–93	53 55		61 30	78 18
1893–94	53 15		50 75	57 80
1894–95	60 10	60 15	68 50	63 68
1895–96	45 22		66 33	73 66
1896–97	45 55		51 22	54 65
1897–98	* *		* *	33 29
1898–99	47 19		50 20	46 45
1899–00	71 31		62 22	* *
Means	53 68	57.46	50 14	56 25

Average of all Stations 54.38. * Doubtful. * * Imperfect.
Lowest two successive years, 1887-8 and 1888-9, average 39.83.

**The maps and plats, part of our proposition, are compilations. The watershed is from the Colfax and Truckee sheets of the U. S. Geological Atlas. The proposed canal line is an original survey made by Mr. Russell L. Dunn for the Giant Gap Water Co. The surveys and estimates of the reservoir sites are preliminary. They were made in part by the Giant Gap Company. The Lake Valley Reservoir was constructed in 1888 and the data concerning it are exact. The Elfland Reservoir and the Upper Pipe Line are from our preliminary survey. The Lower Pipe Line in plan and profile is compiled from topographical sheets of the U. S. Geological Survey Atlas, the maps of Sacramento Valley prepared by State Engineer Wm. Ham Hall and by the Commissioner of Public Works and the Coast Survey Charts. A special survey would probably develop some changes in location on the plats but they would not be material. We regret having to apologize for not presenting an original survey of this part of the line. Lack of time is the explanation. The absence of Mr. Dunn from the State delayed unavoidably the beginning of the preparation for this proposition till December just past.



...MAP...
GIANT·GAP·WATER·SUPPLY·
·CATCHMENT·AREA·RESERVOIRS·
·PROPOSED·FOR·THE·
·CITY·OF·SAN·FRANCISCO·
···SCALE·TWO·MILES·TO·ONE·INCH···

From the table the average seasonal precipitation for the watershed (safely for that portion of it in the sub-watersheds of proposed storage reservoirs, all of which are adjacent to the stations of observation) is 54.38 inches, and the lowest, 1888–89, 39.22 inches. On August 7th, 1889, Mr. R. L. Dunn, of the undersigned, gauged the river at Euchre Bar; the flow was 44,000,000 gallons. On subsequent gauging made August 30th, 1889, the flow was 34,880,000 gallons. The high altitude of the sites of the proposed storage reservoirs, 5,500 to 7,000 feet, and the compact rock surface restricting seepage, are the basis for the assumption that over 70 per cent. of the precipitation, the facilities being provided, can be stored.

PURITY OF THE WATER FROM THE WATERSHED.

The water of the watershed is soft, clear, exceptionally pure, and all that is desirable for the domestic and industrial use of a great city.*

The watershed is very sparsely settled. Three unimportant railroad stations, Shady Run, Blue Cañon and Emigrant Gap; two sawmills near the latter place, and some scattered mines, have the entire population which does not exceed 250. The character of the topography, and the existing mining and lumbering resources, preclude the development of industry increasing the population. Within the subsidiary watersheds of the proposed storage reservoirs there are neither mines nor sawmills, and no human habitations. Contamination of the supply does not exist and the physical and industrial conditions preclude its development in the future.

Physically the watershed is divisible into two sub-catchment areas. The river forks just above the diversion point at Euchre Bar. The right hand branch is known as the South Fork of the North Fork and has much the larger watershed area. The left hand branch is known as the North Fork of the North Fork. Its catchment area includes the railroad settlements of Shady Run, Blue Cañon and Emigrant Gap, the two sawmills and entire lumber industry, and a third of the mining. The status of the land titles in the two watershed areas is about as follows:

		North Fork of North Fork Watershed	South Fork of North Fork Watershed	Total
Public Land		7,360 Acres	45,460 Acres	52,820 Acres
C. P. R. R. Grant		4,400 "	44,300 "	48,700 "
Private Owners	Mining Claims	2,300 "	4,700 "	7,000 "
	Timber Lands, Etc.	20,340 "	6,840 "	27,180 "
		34,400 Acres	101,300 Acres	135,700 Acres

GENERAL PLAN OF WORKS.

The general plan of the system of works suggested, contemplates:

(1) In connection with storage of water, the complete clearing from floodable areas in all of the reservoir sites of standing and fallen timber, and undergrowth, and the excavation and removal of meadow surfaces of decaying vegetation, as essential preliminaries to the construction of impounding dams.

(2) The diversion of the water from the river into the head of a canal at Euchre Bar at an elevation of 1960 feet, and the conducting of the water by the canal 51¼ miles to the Elfland (line) reservoir situated at Bowman.

The headworks are located above the inflow of hydraulic mining debris. The canal line is entirely below the line of snowfall. It is on south-facing steep cañon slopes on which there is no settlement existing or probable. The gulch and ravine drainage of the plateau country above the cañon slopes, descending toward the canal, would be diverted either over or under it, thus protecting the supply against possible contamination en route.

(3) The conducting of the water from the Elfland reservoir near Auburn, elevation 1575 feet, by steel pipe, 16½ miles, to the †Orange (line) reservoir near Roseville, elevation about 300 feet.

*Mun. Rep. S. F. Water Supplies, p. 852, par. 4.

†This proposed reservoir is the site of the first Orange Orchard in Placer County. It is placer mining ground of good value and could be successfully exploited as an incident of the necessary dam construction. That would mean practically that the cost or part of the cost to the contractor of moving into place the structural material for the dam would be taken in gold out of the material while it was being moved.

For service solely as a conduit for the water this would be a single line of pipe having a free discharge.

For service for the development of power as well as for a water conduit, two or more lines of pipes are suggested each (with free discharge) of capacity of flow at least equal to the daily City requirement.

(4) The conducting of the water by pipe from an intake, elevation about 275 feet, at the Orange reservoir near Roseville, 111½ miles, to a free discharge into a receiving reservoir in San Francisco at an elevation of about 25 feet. The line of this pipe would be adjacent to the rail road, crossing the Sacramento River just north of the mouth of the American River, Carquinez Straits at Vallona, passing through Oakland via San Pablo Avenue and Market Street, and crossing the Bay of San Francisco from Alameda Point to South San Francisco. (See Map.)

PUMPING DISTRIBUTION FOR THE CITY.

The City distributing system, as a consequence of the preceeding suggested supply system of works, discharging into its receiving reservoir at an elevation above mean low tide of only 25 feet, would be wholly a pumping system, none of the water being distributable, under proper surface pressure, by gravity from so low an elevation.

THE WORKS A COMBINATION SYSTEM.

The system then, considered as a whole, is what may be termed a "combination system", gravitation in the supply portion, and pumping in the distribution portion.

With a source of supply so much higher than the area of distribution, the first, and apparently the true conclusion, would be, that a distribution by direct gravitation from the source of supply would be the least costly, and that as an economic consequence the most desirable system would be one entirely independent of pumping. This most desirable conclusion has been quite generally accepted as if it were not only true but axiomatic and so not requiring demonstration. In questioning its correctness with reference to the utilization by the City of the particular source of water supply here proposed, we have considered it not inappropriate to present the reasons and comparative cost figures, on which our contrary opinion is based, in such detail as to be intelligently followed by the non-technical investigator.

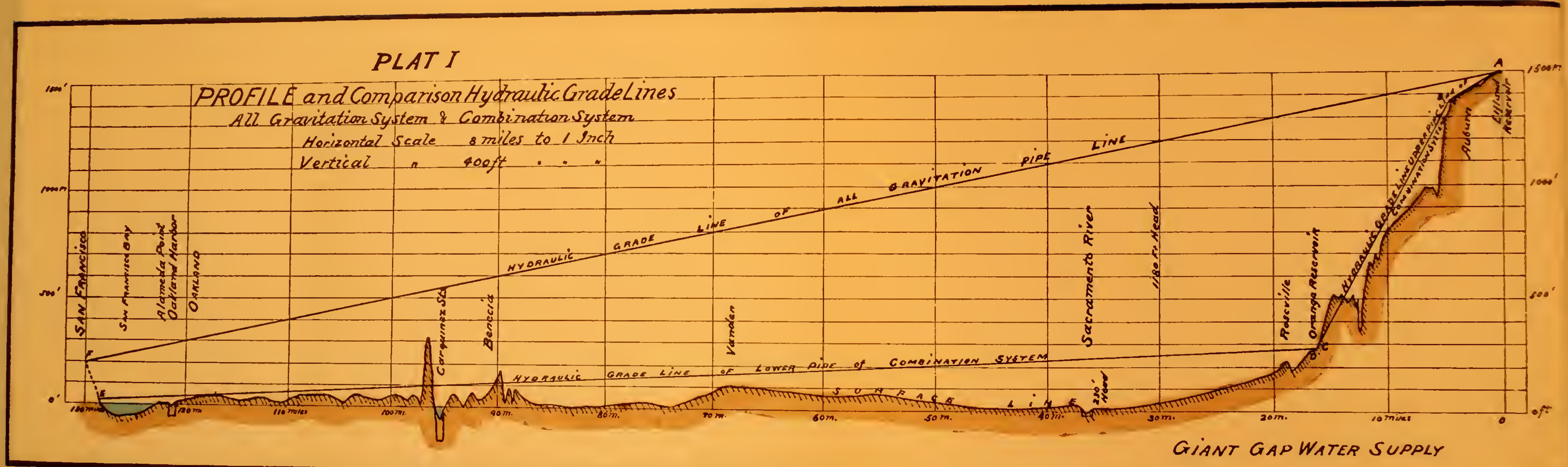
For the purpose of concrete demonstration, assuming the economic problem as being the average supply to the San Francisco distribution of 30,000,000 gallons daily, the question is: the source of supply being the North Fork of the American River; Which is the least costly—to supply this water by a gravitation system of works solely, or by a combination system, gravitation for the supply, and pumping for the distribution?

SEASONAL VARIATION OF SUPPLY REQUIREMENT.

An average daily supply of 30,000,000 gallons is the resultant of seasonal variation between extremes of a lower daily requirement in winter and a greater daily requirement in summer. We have no information of what are the exact facts as to such variation of requirement on the Spring Valley system. From the records of other cities, and taking into account the exceptional climatic conditions here, we assume such variation to be, either way from the mean, approximately 17 per cent., so that the maximum daily requirement based on average of 30,000,000 gallons is 35,000,000 gallons. The pipe conduit of either system must therefore be provided to have 35,000,000 gallons capacity of daily flow with free discharge, and by free discharge is meant the simultaneous discharge of all the water the pipe will flow, using the power of its entire fall for that purpose alone.

DISTRIBUTION REQUIREMENTS OF CITY.

The water requirement of the City is such that three-fourths of the consumptiou can be properly provided for by supply delivery into the distributing system at 200 feet elevation. For what is considered the all-gravitation system, a City delivery of the supply conduit at 200 feet elevation is reasonably to be considered as satisfying the conditions, and the fourth of the water requiring distribution at elevations above 200 feet is pumped from the 200-foot elevation. It is obvious, that as the same quantity of water (which must be pumped), requires distribution above 200 feet elevation in either system, this high distribution need not be considered. Also the current operating expenses of the two pipe conduits compared, being equal, are also eliminatable. Finally then, the difference in cost (both installation and current operation) between the two systems, would be practically only the difference between the cost of the respective pipe conduits, with the addition of the


PLAT I
PROFILE and Comparison Hydraulic Grade Lines
All Gravitation System & Combination System
Horizontal Scale 8 miles to 1 Inch
Vertical " 400 ft " "
HYDRAULIC GRADE LINE OF ALL GRAVITATION PIPE LINE
HYDRAULIC GRADE LINE OF LOWER PIPE OF COMBINATION SYSTEM
SURFACE LINE
HYDRAULIC GRADE LINE UPPER PIPE
COMBINATION SYSTEM
SAN FRANCISCO
San Francisco Bay
Alameda Point
Oakland Harbor
OAKLAND
Carquinez Sts
Benecia
Vanden
Sacramento River
1180 Ft. Head
220' Head
Roseville
Orange Reservoir
Auburn
Lilliard Reservoir
A
F
E
1500'
1000'
500'
0'
1500 Ft.
0 ft.
120 m.
110 miles
100 m.
90 m.
80 m.
70 m.
60 m.
50 m.
40 m.
30 m.
20 m.
10 miles
0
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cost of pumping (installation and operation), to the cost of the pipe conduit of the combination system.

Eliminating from the first cost of the two pipe lines, the cost of common constructions, the difference of first cost is ultimately in the difference between the quantities of steel in the pipes, and the difference in the amounts of mechanical work on the steel.

PROFILE OF PIPE CONDUIT.

Plat No. 1 is a profile of the surface in the line in which the pipe conduits would be built from the reservoir near Auburn to San Francisco. The vertical scale of the drawing referred to the horizontal scale is exaggerated, being 105 times greater.

DESCRIPTION OF ALL-GRAVITATION CONDUIT.

*The all-gravitation conduit would be a steel pipe 48 inches in diameter, having its intake end at the Elfland reservoir at 1500 feet elevation ("A" on Plat 1), thence continuous, in the surface line "A-B-C-D-E-F" delineated on the plat, 130 miles, to a free discharge in San Francisco at 200 feet elevation ("F" on Plat 1.)

DESCRIPTION OF GRAVITATION PORTION OF COMBINATION SYSTEM.

The gravitation portion of the combination system would be, first a steel pipe 42 inches in diameter from "A" to "B" (4.5 miles), at "B" decreasing in diameter to 34 inches and continuing 12 miles to "C", where there would be a free discharge into the Orange reservoir; and second, at "D", a second intake, and thence a steel pipe 61.25 inches in diameter, 111.5 miles to "E", the point of a free discharge in San Francisco at 25 feet elevation. The pumping portion would be the vertical pump-lift of the water from "E" to the level of "F", 175 feet. The first described pipe conduit will be referred to hereafter as the "Upper Pipe Line" and the secoud pipe will be referred to as the "Lower Pipe Line."

HYDRAULIC GRADE LINE, HYDRAULIC HEADS AND HYDRAULIC PRESSURES.

Referring again to Plat 1, the straight line drawn from "A" to "F", (from the intake to the free discharge point of the all-gravitation pipe line), is what is known in the Art as the "Hydraulic Grade Line" of the water flow of that pipe. Similarly the straight lines, "A B"—"B C", constitute the hydraulic grade line of the flow of the pipe projected between the two line reservoirs, and the straight line "D–E" is the hydraulic grade line of the flow of the pipe projected from the Orange Reservoir to San Francisco. All of the projected pipe lines are what are termed "Inverted Siphons." The line of actual water flow is everywhere between intake and discharge below the hydraulic grade line, and the pipe, discharging free, flows full. The pressures of the flowing water on the steel of the pipes are, at all points of the lines, in direct ratio to the vertical distance from the point to the hydraulic grade line above it. This distance is described as the "Pressure Head" For each foot of it the added pressure is .434 lbs. to the square inch.

On Plat 1 the pressure heads can be easily scaled, or can be roughly approximated without scaling by counting the horizontal lines between, which represent differences of 100 feet vertically. The pressures in pounds per square inch are obtained by multiplying the heads by .434.

EXTREME PRESSURE HEADS ON PIPES.

It will be noted that the extreme pressure head on the all-gravitation pipe would be 1180 feet, resulting in a pressure on the steel of the pipe of 512 lbs. to the square inch. The extreme pressure head on the lower pipe of the combination system would be 220 feet, resulting in a pressure of 95 lbs. to the square inch. This last is only half of the higher steam boiler pressures employed industrially while the former is three times such pressures. It will also be noted, that practically the entire all-gravitation pipe line would be under pressure heads largely exceeding the extreme head on the pipe of the combination system.

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*In calculation of discharge of pipes we have employed D'Arcy's Formula. (1) $v = 113.8\sqrt{r.\,s.}$ in which v = velocity of flow, r = (2) hydraulic radius, ¼ the diameter of the pipe, and s = the slope per mile in decimal of a mile. From the diameters of riveted pipe 1¼ to 1½ inch was deducted for the rivet heads.

SAFETY FACTOR AND THICKNESS OF STEEL PLATES REQUIRED.

In order that each of the pipes should have the same margin of safety against bursting under the hydraulic head (2½ times the strength that would just equal the bursting pressure is a safe margin), the steel that would be used in manufacturing the pipes of the all-gravitation line must be much thicker than required of the steel that would be used for the lower pipe of the combination system. The steel plates for the 20 miles of the all-gravitation line under the greatest hydraulic pressure heads would have to be from ½ to 6–10 of an inch thick. All of the lower pipe line of the combination system would be manufactured of sheet steel 5–32 inch (No. 9 American Gauge) thick, and at the point of greatest pressure head would be not only 2.5 times safe, as calculated for the all-gravitation pipe, but 2.8 times safe. This thickness of steel we take as the least (though No. 10 thickness could be used) that would be mechanically desirable for a pipe of the proposed diameter *

DIFFERENCE OF QUANTITIES OF STEEL REQUIRED AND COST.

It can be readily apprehended that the difference between the two pipe conduits, in the total quantities of steel that would be required, is enormous. Also that the cost of manufacture and placement of the thicker of the steel plates required for the all-gravitation system would be more per pound of steel. Our estimate of the difference in the weights of steel that would be required is 112,000,000 pounds, and we calculate that the excess of cost of the pipe conduit of the all-gravitation line over that of the combination system would be $7,000,000.

PUMPING PLANT OPERATION.†

The cost of a pumping plant to lift 30,000,000 gallons daily, 175 feet, could be made to approximate $450,000.

The annual cost of operation of the pumping plant using coal at $5.25 per ton would be...... $116,000

With crude oil, at $1 per bbl., for fuel the annual cost of operation would be 75,000

If, (as is commercially practicable) the water power of the fall from the Elfland to the Orange reservoir be developed and transmitted as electric power to San Francisco, its use in the pumping plant will reduce the annual cost of operation to............. 51,000

In all three of the above estimates of annual cost of operation an allowance of 4 per cent. is made to replace depreciation of plant.

DIFFERENCES OF CAPITAL INVESTMENT IN THE TWO SYSTEMS.

The net differences of capital investment against the all-gravitation system are:

Using coal or oil for pumping fuel......	$6,550,000
Using transmitted electric power	6,250,000

*The commercial grade of sheet steel proposed has a tensile strength of 75,000 lbs. to the square inch. Double riveted, and with a safety factor of 2½, the maximum strain on the pipe would be 21,000 lbs. to the square inch. Only a small fraction of the length would be under this amount of strain and over half of it would be under strains from 10,000 lbs. to the square inch, and less.

†In all estimates herein stated, coal is assumed to be Wellington screenings at $5.25 a ton. In calculating its water lifting duty the actual result obtained in the City of Buffalo pumping plant in 1899 using soft bituminous coal is employed. There, it required 16.67 lbs. coal to lift 1,000,000 gallons 1 foot. Petroleum, estimated as to cost at $1 per bbl., is estimated as having an evaporative power of 13 lbs. of water for 1 lb. of oil. The estimates of electrical utility of the water power are based on the offer of guarantee of a responsible electrical company. Time of employees is estimated at 8 hours and the wage scale 10 per cent in excess of current rates. In the number of employees for the service a more than liberal allowance has been made. The aim has been to prepare estimates which actual operation would prove too high rather than too low. Maintenance which includes repairs and replacement we have estimated as if it were an operative fund with an insuring income to meet the variations of actual requirement. The percentages estimated have been approved by practice as affording a safety margin.

DIFFERENCES OF ANNUAL COST CHARGES.

The comparative statement of annual cost charges would be as follows: (The interest and sinking fund items are calculated so as to equalize the respective capital investments at the end of 40 years.)

WITH PUMPING FUEL, COAL.

Making the comparison on the basis of coal at $5.25 a ton as the pumping fuel; there would be chargeable to the all-gravitation system:

1.	Interest at 3.5 per cent. on $7,000,000	$245,000
2.	Maintenance of pipe plant, 1 per cent. on $7,000,000	70,000
3.	Sinking Fund to repay in 40 years $4,235,700, the difference between $7,000,000 and $450,000 plus $3,314,300, the capitalization at 3.5 per cent. of $116,000 annual expense of operating pumping plant using coal at $5.25 a ton for fuel. (The estimation made in this manner equalizes the investment in 40 years. Expenditure for coal can be treated for this purpose as if it were interest on an investment.)	22,850
	Total	$337,850

Against the combination system there would be chargeable:

1.	Interest at 3.5 per cent. on $450,000	$ 15,750	
2.	Operating expenses with coal at$5.25 a ton for fuel	116,000	$131,750
	Difference annual saving of the combination system		$206,100

WITH PUMPING FUEL, PETROLEUM.

Making the comparison on the basis of using petroleum fuel at $1 per bbl. in the pumping plant:

ALL-GRAVITATION SYSTEM.

1.	Interest	$245,000
2.	Maintenance and Replacement	70,000
3.	Sinking Fund (determined as above)	31,250
		$346,250

COMBINATION SYSTEM.

1.	Interest	$15,750	
2.	Operating Expenses (oil for fuel at $1 per bbl.)	74,350	$90,100
	Difference annual saving of the combination system		$256,150

WITH WATER POWER ELECTRICALLY TRANSMITTED.

Finally making the comparison on the basis of using the transmitted electric power in the pumping plant.

ALL-GRAVITATION SYSTEM.

1.	Interest	$245,000
2.	Mainteuance aud Replacement	70,000
3.	Sinking Fund	33,850
		$348,850

COMBINATION SYSTEM.

1.	Interest (Pumping Plant)	$15,750	
2.	Interest (proportion of Electric Plant Investment)	10,500	
3.	Operating Expenses (Electric Power)	51,000	$77,250
	Saving in favor Combination system		$271,600

The annual saving using the transmitted electric power, cumulated with interest at 3½ per cent. for 20 years would rebuild the entire water supply system.

The preceding estimates have been made with great care and we believe fairly present the argument of the economic problem. Differences of opinion as to details may modify the figures somewhat but cannot change the conclusion they demonstrate.

PHYSICAL DIFFERENCES IN FAVOR COMBINATION SYSTEM.

Independent of the money difference to the preference of the combination system, there are physical differences that favor it; differences in construction, in operation and maintenance, and a very considerable difference in the possibility of expansion of the delivery to satisfy the constantly increasing water consumption of the City.

COMPARATIVE CONSTRUCTION OF CARQUINEZ TUNNEL.

In the construction of the all-gravitation line the pipe would have to be built through the tunnel under Carquinez Straits, as a consequence of the great pressure head (550 feet, 238 lbs. per square inch). In the combination system, the tunnel itself lined with brick or concrete would perform the service of the steel pipe, the maximum pressure head being only 130 feet, 56 lbs. per square inch. The heads for both lines are measured from the sea level up to the hydraulic grade line. The internal pressure of the water column below the water level in the Straits, would be balanced by an external pressure from the water column of the sea water. This is on the presumption that a pipe would be concreted solidly in place in the tunnel. If left free in the tunnel, and the latter kept clear of water to admit of inspection, the pipe would be under the additional internal pressure head of the depth of the tunnel below the sea level. The Carquinez Tunnel for the all-gravitation line would require to be excavated with a much greater area of cross section, and would require a proportionally greater quantity of concrete or brick lining.

CONDITIONS OF CONSTRUCTION OF OAKLAND HARBOR TUNNEL SIMILAR TO CARQUINEZ.

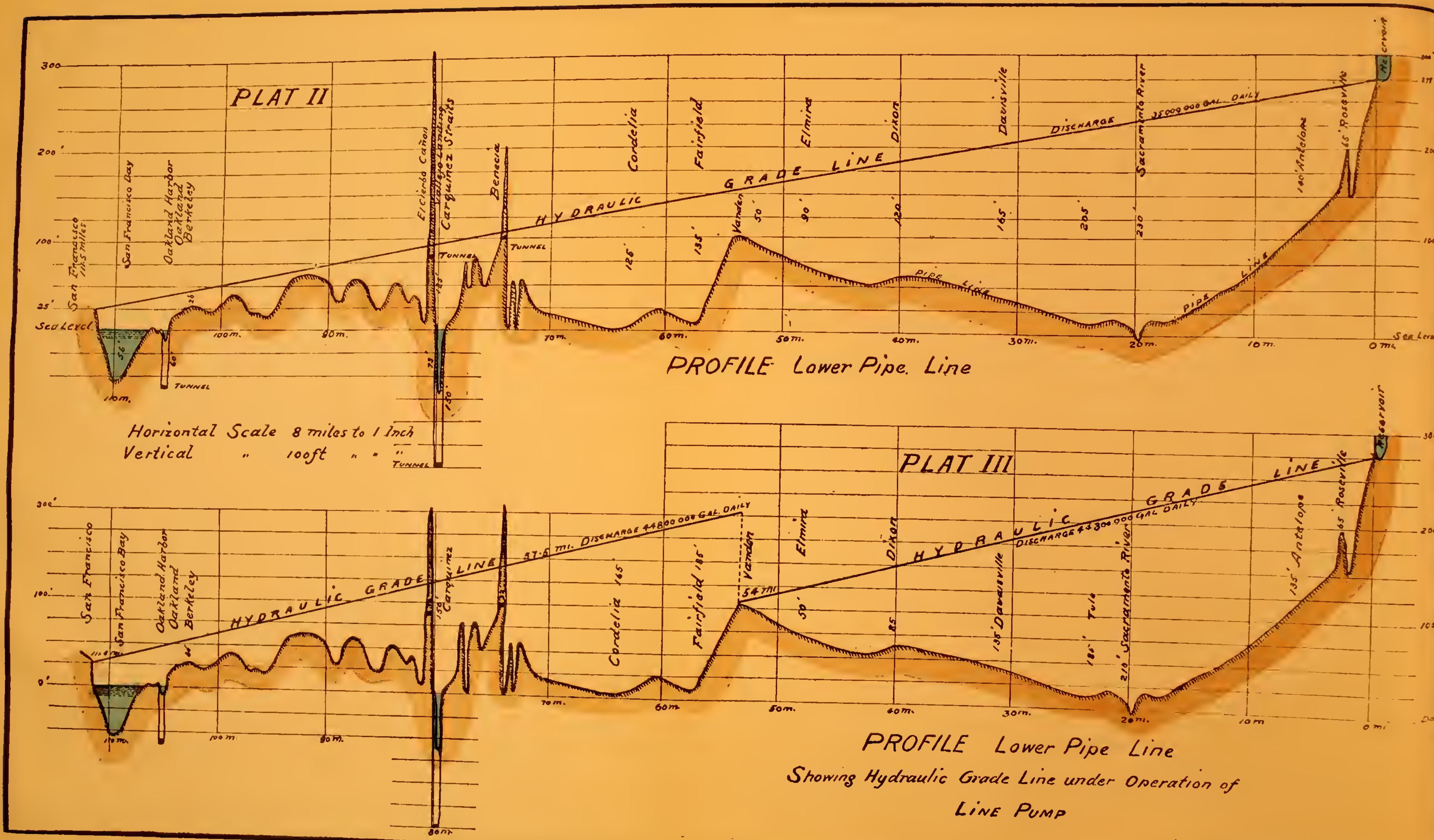
The same conditions would apply in the construction of the tunnel under Oakland Harbor. Unless the formation should prove much less suitable than we have reason to believe, the conduit for the combination system would be the tunnel either brick or concrete lined.

DIFFERENCES IN OPERATIVE CONDITIONS.

In operation, the all-gravitation line would require inspection more frequently and with a higher degree of technical skill. While the safety factor of both pipes would be ample against the respective hydraulic heads, in the possible event of an accident partially or wholly suppressing the flow, there is no portion of the pipe of the combination system (this refers to the Lower Pipe Line), in which the static pressure of the water (the static pressure head being measured up to the line of the level of the inlet), taking the place of the hydraulic pressure, could burst the pipe. In the all gravitation pipe, the pressure of the static head on miles of the San Francisco end of the pipe would result in breaking it at some point. The possible static head on any point of the pipe of the combination system would be 275 feet, 120 lbs. to the square inch, but a pressure of 266 lbs. to the square inch would be required to breach the pipe so that even under extreme static head the pipe of the combination system has a factor of safety of 2.2. The possible static head on the pipe of the all-gravitation line would be 1500 feet, 651 lbs. to the square inch. Of the pipe, 40 miles would have less than the strength to balance this pressure.

COMPARISON OF MAINTENANCE CONDITIONS.

Maintenance, or repairs, on the all-gravitation line would be more difficult and expensive. A system of gates, such as would be placed on the pipe of the combination system, cannot safely be used, as the closing of a gate would put the pipe under static pressure outside the safety limit. The water must then be emptied from the entire line of pipe for the slightest repairs that may have to be made, and both emptying and filling such a siphon would be slow operations, and require great mechanical skill to avoid breaches or the development of leaks. In addition to the actual time of the repair work, which might be only a few hours, from 2 to 5 days would be required to empty and fill the pipe, thus necessitating a considerable reserve storage in San Francisco. Using ordinary precautions the pipe of the combination system can be gated down at any one or more of a number of conveniently placed points, so that the interruption of the flow could be limited to little more than the actual time of the repair work. It is reasonable to assume that the necessity for repairs will come much the less frequently with the pipe line under low pressure heads. A break from external causes (for a break from internal strain is all but an impossibility) in the line of low pressure heads would be



GIANT GAP WATER SUPPLY

localized to the point of the break. The effect of a break in the pipe line under high pressure heads very probably would extend to other and distant points, making both visible and latent injury, the existence of the latter only appearing when the pipe is put in operation again.

COMPARATIVE POSSIBILITIES OF EXPANSION.

In the possibility of expansion of the delivery to meet the successive increments of increase of consumption by the City, the combination system we suggest is far superior to the all-gravitation system.

The increase in consumption is not by jumps, so to describe, of several million gallons daily at a time, but is a gain of small increments, cumulating 1,000,000, 2,000,000 or 3,000,000 gallons additional it may be, in a single year. The following table is submitted as indicating this gain, with, we believe, a fair approximation to the probabilities:

TABLE II.

YEAR	POPULATION	PER CAPITA DAILY	TOTAL DAILY
1890	Of. 298,997	71	21,400,000
1900	" 342,782	74	25,400,000
1903	Est. 360,000	75	27,000,000
1905	" 370,000	75	28,000,000
1908	" 390,000	76	30,000,000
1910	" 410,000	78	32,000,000
1913	" 430,000	78	33,000,000
1915	" 450,000	79	35,000,000
1918	" 480,000	80	38,000,000
1920	" 500,000	81	41,000,000

DUPLICATION OF CONDUITS TO MEET INCREASE OF CONSUMPTION.

The combination system suggested by us is particularly designed to be flexible, if the use of the word is permissible to describe the idea, to this gradual gain from year to year. It is obvious that when the consumption reaches the limit of the full gravitation delivery of the pipe, the supply could be increased by constructing a second line of pipe conduit, but that, as such new lines could not economically be built to provide the additional demand of a single year, they must when built have a capacity sufficient to anticipate the demand of a considerable term of years.* Thus the duplication of the conduit means the investment of capital in advance of the service which is to repay it. The fixed charges of the investment, interest and sinking fund, and the operation and maintenance of the added plant pending its full utilization, thus would become charges on the consumers who must pay higher rates for the water they actually consume, and in actual fact pay a penalty for providing water supply for water consumers of the future.

The same commercial reasons apply in comparing a water supply from natural sources, such as lakes, rivers, or as in our proposed source, snow banks and springs, with a supply from artificial reservoirs. Investment in the latter naturally must anticipate more or less distant future consumption, but in doing so forces present consumption to pay fixed charges on dead capital. Conditions change the amount of this payment, but it is inevitably something; with low inexpensive dams very small, with high expensive dams very much.

PROJECTED LINE PUMPING PLANTS OF COMBINATION SYSTEM.

Referring to the map, about half way between Suisun and Elmira, there will be noted a place named "Vanden". Travelers by rail to Sacramento will recall it by an orchard and vineyard situated at the foot of a hill west of the track—the only hill touching the track line between Suisun and Sacramento. Plat I shows the point in profile. Plat II, which is a profile of the Lower Pipe Line of our suggested system, similarly, and more conveniently shows it with the vertical scale of the drawing exaggerated with reference to the horizontal 420 times. It will be noted that the elevation above the sea level of Vanden is about 100 feet, and that the hydraulic grade line of the pipe would be about 54 feet above the surface, putting on the pipe a hydraulic head of 54 feet at this point.

*Municipal Report, 1876-77; p. 252, par. 4 and 5.

As a part of our suggested system, and for the special purpose of increasing the daily delivery of water in exact correspondence with the actual requirement for increasing consumption, we propose at this point, at the time when the consumption of the City shall equal the maximum gravitation delivery of the pipe conduit, the construction of a pumping plant, its duty to be the increasing of the velocity of flow, so that the pipe shall deliver the increased consumption required.

PRACTICAL OPERATION OF VANDEN PUMPING PLANTS.

In operation, the practical working of the pumping plant is explainable by reference to Plat III, the same profile as Plat II, with hydraulic grade line corresponding to 8,000,000 gallons of increased delivery In effect, the pipe conduit is here cut into two sections, not actually, be it understood, but in operation as if it were so. To the upper section, an additional total fall is given which shall just increase the velocity sufficient to deliver at Vanden the added requirement of consumption. This is to be effected by discharge into a standpipe*, so constructed that the elevation of the discharge above the sea level is exactly controlable between 90 feet, which would be in a pit about 10 feet below the surface, and 175 feet, which would be about 75 feet above the surface. The height of the standpipe would thus be about 100 feet, 20 feet of it being constructed in excavation. The pumping plant intake would receive the entire augmented flow at the elevation of the standpipe delivery above the surface, and would give it a thrust pressure in the lower section of the pipe, equivalent to a hydraulic pressure head, which, added to the natural gravitation head from the standpipe inlet to the San Francisco discharge, would give to the water the same velocity of flow as in the upper section of the pipe. The pump is so arranged that its intake has on it the standpipe pressure, so that the lifting work it has to do begins at the level of the water in the standpipe, whatever that level may be.

There is nothing novel in the principle employed. The pumping plant of the Spring Valley Company at Belmont is the nearest application of it to which we can refer. At Sunol, the water of Alameda Creek is taken into a pipe at an elevation of something over 100 feet, and conducted by gravity about 20 miles to Belmont, where it is discharged into a receiving reservoir about sea level elevation. The maximum full flow of this pipe is claimed to be 12,000,000 gallons daily, but the supply of the stream, very variable, is ordinarily much less than this amount, 7,000,000 to 3,000,000 gallons and even less, and the pipe discharging into a fixed level reservoir does not with these lesser deliveries run full to the inlet. The pump thus has the duty of delivering a variable quantity of water, less than the full gravitation flow of the pipe, and it takes this water from the receiving reservoir and lifts it into a standpipe, giving it a fixed standpipe head for its delivery into the Crystal Springs pipe at San Mateo. Fuel consumption varies with the quantity of water lifted, but the pressure head of the lift is invariable. If the standpipe of this Belmont works, arranged for a variable level of discharge, was on the intake end of the pumps instead of the delivery end, the Belmont works would be an exact illustration of the principle proposed for application with our suggested system, and the pump lift and its corresponding cost in coal consumed would be reduced by the use of the delivery heads of the full pipe with less than maximum flow. Singularly enough the uneconomical installation of the Belmont plant seems to have been overlooked by the water consumers of San Francisco who have for fourteen years paid the coal bills that might have been saved by a proper installation.

To those of you who are miners the experience you have had in unwatering a flooded mine with a submerged Cornish or lift pump is a practical example of this simple principle in pump operation. You have undoubtedly noticed than when the pump is deeply submerged it pumps with less expenditure of power than when it is less submerged or uncovered. The reason of course is that while submerged the water column in the delivery pipe from the pump was balanced as far up as the surface of the water submerging the pump and the latter in actual work did not lift the entire column from the pump to the discharge, but only that portion of the column from the surface of the submerging water to the discharge. As the depth of the latter decreased under the pumping the work of the pump and the expenditure of the power it required increased. Now the Belmont pumping plant has precisely the relation to the duty of taking water from Alameda Creek to Sunol and delivering it into another conduit at San Mateo that the submerged pump has to unwatering a mine. And it is as well the same relation that the Vanden pumping plant would have to the delivery of water from Giant Gap to San Francisco.

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*The standpipe is not indispensible, the pump can be used in the pipe line just as in the oil-carrying pipe lines in Pennsylvania.

WHEN CONSTRUCTION OF LINE PUMPING PLANT WOULD BE MADE.

In the construction of the Lower Pipe Line of our suggested system, preparation for the addition of the pumping plant would be made by a proper system of gates making the beginning of a loop, which would be completed when required by the standpipe and pumping plant. The cost of the gates, not more than $10,000, would be the entire construction cost of provision for increased consumption, until the latter commenced to exceed the capacity of the gravity flow of the pipe. If population and consumption should increase about as indicated by our tabulated estimate, and our suggested system be constructed within the next three years, the pumping plant would require to be constructed four or five years later. The cost of the required plant to use coal or oil we estimate would be $180,000; an installation to use electric power we estimate would cost $100,000.

ANNUAL OPERATIVE COST OF LINE PUMPING PLANT.

We have prepared Table III to show the estimated annual operative cost of the suggested line pumping plant, with daily delivery from 30,000,000 gallons average to 38,000,000 gallons average. The corresponding maximum delivery would be from 35,200,000 to 44,800,000 gallons. To secure the average deliveries the pumps would not require to be operated continuously, but only for the portion of each year when the consumption requirement exceeded 35,200,000 gallons.

TABLE III.

Showing annual operative costs of the Line Pumping Plant with different deliveries.

Average Million Gallons.	Maximum Million Gallons.	Annual Operative Cost.		
		Coal Fuel $5.25 per Ton.	Oil Fuel $1.00 per Bbl.	Water Power By Electric Transmission.
30	35.2			
31	36.4	$ 1,146	$ 843	$ 788
32	37.6	4,029	2,927	1,657
33	38.8	7,303	5,146	2,654
34	40.	10,505	7,928	3,770
35	41.2	17,655	11,935	5,292
36	42 4	24,085	16,064	6,752
37	43.6	31,178	20,622	8,344
38	44.8	41,453	25,967	10,482
		$137,354	$91,432	$39,739

Table IV shows the absolute cost per 1000 gallons of the added water delivery, both operative and fixed charges being included. The latter allow 3½ per cent. interest on investment, 1 per cent. replacement on conduits and 4 per cent. on machinery and buildings, and 0.7 per cent. for sinking fund to write off investment.

The cost figure, 5.06 cents per 1000 gallons for the original gravitation delivery is advanced from the result of a detailed estimate set forth further on.

TABLE IV.

Absolute cost in cents per 1000 gallons of the added deliveries (operating and fixed charges).

(1) Average Daily Million Gallons.	(2) Maximum Daily Million Gallons.	(3) Coal Fuel $5.25 per Ton.	(4) Oil Fuel $1.00 per Bbl.	(5) Water Power Electric Transmission.	(6) Cost of 1000 Gallons of Original Delivery of 30,000,000 Gallons.	(7) Mean Cost per 1000 Gallons for Oil Fuel.	(8) Mean Cost per 1000 Gallons Whole Supply Water Power.
30	35.2				5.06 cts.	5.06 cts.	5.06 cts
31	36.4	4.814	4 731	5.826	5.06	5.05	5.08
32	37.6	2.808	2.651	3.047	5.06	4.90	4.93
33	38.8	2.167	1.970	2.172	5.06	4.78	4.80
34	40.	1.193	1.665	1.698	5.06	4.66	4.66
35	41.2	1.867	1.554	1.430	5.06	4.56	4.54
36	42.4	1.850	1.483	1.277	5.06	4.46	4.43
37	43.6	1.863	1.450	1.203	5.06	4.37	4.33
38	44.8	1.982	1.492	1.149	5.06	4.31	4.23
Average	....	2.06 cts.	1.69 cts	1.60 cts.			

It must be understood that the annual costs given in Table III are the total costs for pumping the original 30,000,000 gallons as well as the added increment. In Table IV, columns 3, 4 and 5, the costs are only on the added increment. That is the particular water that necessitated the pumping and it should therefore be charged with its entire cost. Columns 7 and 8 are the averaged costs of the entire delivery.

It will be noted at a glance that the absolute cost of the added water at any rate of increased delivery, using coal, oil or water power, is less than the cost charge of the original delivery, and also that the water power is less costly than the use of fuel. The effect of the lower cost charge of the added water delivery is to reduce the cost charge of the entire delivery, so that the consumers receive a premium for providing for an additional consumption instead of being fined by higher cost charges as would be the case if instead of our suggested Linc Pumping Plant, a second pipe conduit was constructed.

The certainty of a supply cost charge reduction with increased consumption of water is sufficiently a novelty in this city to invite your attention. We have prepared Table V, to show what the effect of the increase of population, and increase of water consumption, has been on the investment per unit of water delivered by the Spring Valley system.

TABLE V.

Showing effect of increased population and water consumption on the cost charges of delivery of water supplied by the Spring Valley system.

Year.	Population of San Francisco.	Investment Spring Valley Stock and Bonds	Investment per Capita	Mean Daily Water Supply	Capital Invested per 1,000,000 Gallons	Expenditure Required to Provide 1,000,000 Gallons Additional Daily Delivery.
** 1875	Est. 190,000	† 8,750,000	$45.00	11.4 M	$ 767,000	
* 1880	Of 234,000	12,130,000	51.80			
* 1885	Est. 265,000	14,300,000	54.00	17. M	841,000	$1,101,000
* 1890	Of 299,000	20,200,000	67.56	††21.4 M	944,000	
* 1895	Est. 321,000	22,450,000	70.00	19.9	1,128,000	
* 1898	Est 333,000	25,275,000	76.00	24.6 M	1,027,000	1,644,000
1900	Of 342,000	26,775,000	78.00	††25.4 M	1,054,000	
1908	Est. 390,000	*** $37,455,000	$96.00	30. M	$1,248,500	$2,304,000

** Municipal Report 1876-77, p. 810.
† Municipal Report 1875-76, Water Supplies, p. 42.
* From Official Statement of the Company to the City. Municipal Report 1898-99, Water Rates, p. 23.
†† From Official Statement of Spring Valley Co. Engineer to the Board of Supervisors January 25, 1901.
*** This amount is obtained by adding $10,677,000 (the estimate stated in Official Statement of Spring Valley Co. Engineer to the Board of Supervisors January 25, 1901, as the cost of addition to present plant of Calaveras Reservoir supply) to $26,750,000, the existing stock and bond capital. The figure is under to the true amount by the amount by the floating debt, which is unknown to us.

INCREASE OF SPRING VALLEY INVESTMENT REFERRED TO POPULATION AND WATER SUPPLY.

There has certainly been a very regular increase of Spring Valley capital investment per capita of the San Francisco population, the present per capita investment being one and three-fourths times the investment in 1875. The investment representing a daily delivery of 1,000,000 gallons has also been steadily rising, and the investments for the later increments of 1,000,000 gallons delivery increase are greater than for the older increments of similar increase. Increased investment per capita carries with it an increased cost charge for water, and would have resulted in increasing consumers rates but for the reduction of the rate of interest since 1875 carrying 60 per cent. of the increase in cost charge and the municipality the remaining 40 per cent.

The figures based on a mean daily delivery of 30,000,000 gallons, introduced here by reason of being the directly comparable figures with our Giant Gap proposition, illustrate even more forcibly the persistent *cubic* growth of the Spring Valley capital investment. It is not sufficient to say that the expenditure of $10,677,000 will add to existing supplies a quantity that will provide a mean daily delivery of 55,000,000 gallons. The essence of the proposition is, that when you only want 30,000,000 gallons daily you must, under existing commercial conditions, pay for 25,000,000 gallons that you do not want but that someone else *may want* (not

must have) twenty or more years from now, and if then wanting it must then pay for it just the same as if you had not meanwhile paid for it twenty or more times over.

MONEY SAVING OF OPERATION MADE FROM INCREASING CONSUMPTION.

Taking the estimates of population and daily consumption for several years from 1908 to 1918, from Table II, and the costs per 1000 gallons from Column 8 of Table IV, the total cost charges of all the deliveries from averages of 31,000,000 to 38,000,000 gallons daily, would, with interest ot 3½ per cent. added, aggregate $547,000. That is to say, the first 10 year period of increased daily consumption would be provided at so much lower cost charges, that a saving would be made to the municipality, and therefore to consumers, practically equal to the total supply cost for a year of 30,000,000 gallons daily.

PROVISION OF INCREASED CONSUMPTION EXCEEDING 38,000,000 GALLONS DAILY.

When the average daily consumption of 38,000,000 gallons shall be exceeded, provision for increased delivery would *then* be made by the construction in sections of a second pipe conduit. The first section would be 44 miles, 19.5 miles from the Orange Reservoir to the Sacramento River, where it would connect with the first pipe through the conduit crossing the river, and 24.5 miles from Vanden toward San Francisco, which, the tunnels having been built originally sufficiently large, would make this portion of the duplication 26.5 miles long. This construction would provide, with the use of the Vanden Pumping Plant, for increases of mean daily delivery up to 43,000,000 to 47,000,000 gallons (maximum 50,000,000 to 55,000,000), determined by the diameter of the second pipe line.

COST OF CONSTRUCTION OF SECOND CONDUIT PAID BY SAVING OF LINE PUMPING.

The cost of construction of this added section of pipe conduit (for say 25,000,000 gallons free gravitation delivery at the City when completed) could be fully made, or nearly so, from the estimated saving which the preceding operation of the Vanden Pumping Plant would have effected ($547,000), plus the current saving in operative expense of the Vanden Pumping Plant, transferred to interest account and capitalized. The absolute cost per 1000 gallons of a mean daily delivery of 39,000,000 would be 4.18 cents. This is less than the absolute cost per 1000 gallons of the mean daily delivery of 38,000,000 gallons. Referring to the last column of Table IV, it indicates that the ratio of cost reduction would be maintained with increased deliveries, and that an increased annual saving as compared with the cost of the initial delivery would continue to be made. We consider that this saving would, as extensions of the supply system were thereafter required, provide the entire cost thereof in advance.

IMPORTANCE OF LINE PUMPING DEVICE.

We have presented the device of a line pumping plant in detail, regarding it as of exceeding importance in connection with the economical operation and expansion of our suggested plan of works. The comparison with the hypothetical all-gravitation system has been subordinated. Regarding the application of the device to the all-gravitation system, it is sufficient to say that it cannot be applied practically. The expansion of such a system could only be safely effected by duplication of the pipe line. Unless provision were made for it in the construction of the first pipe, by adding to the thickness of the steel used, it could not be done in sections, but the entire line must be made complete before it could be operated.

RECAPITULATION OF COMPARISON OF SYSTEMS.

Recapitulating our comparison of the two systems, the combination system as suggested by us, has these conclusive advantages commending it to your acceptance:

1st. Its initial cost would be $7,000,000 lower.

2nd. Its current cost of operation would be 50 per cent. lower by reason of lower capital investment.

3rd. It would be not only safer relatively, but would be safe absolutely.

4th. It would provide the entire capital cost of extensions of the works from the lessened cost charges that the use of those extensions will secure.

MOUNTAIN STORAGE RESERVOIRS.

In our proposed source of water supply, the snow banks and springs are the great storage reservoir, the river is their natural collector and conduit to the diversion point. As already stated, the river flow, independent of any lake storage, would supply the requirements of the City's consumption for 8½ months of each year. The flow of the remaining 3½ months is just about sufficient for the requirements of the present or for a few years in advance.

The service of artificial mountain storage is then, first, to insure against the risk of an extraordinary shortage in the supply from the natural reservoirs of snow banks and springs, and second, to provide the additions to the future consumption that can be anticipated. Incidentally, if a power development from a 100,000,000 gallon daily supply be desired storage would be required for this purpose.

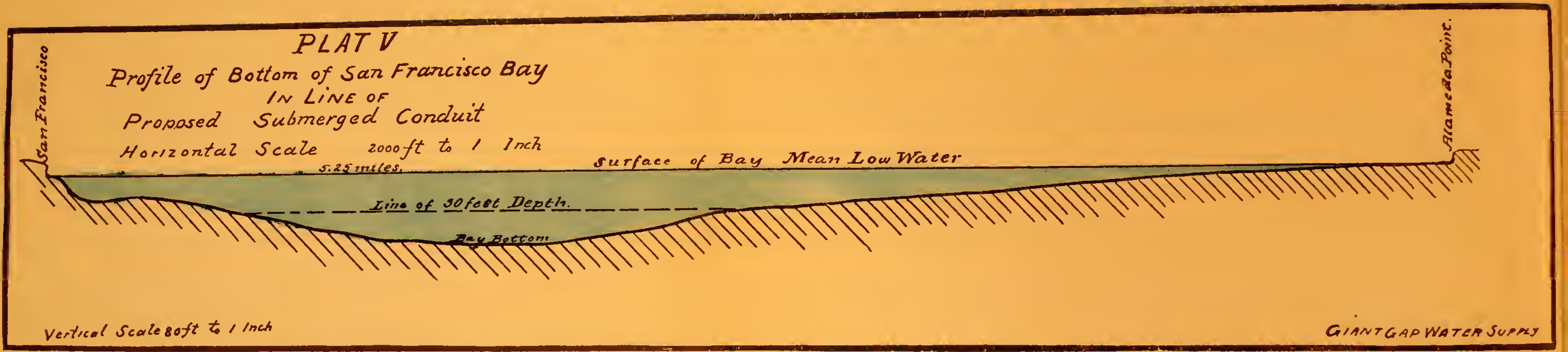
AMOUNT OF ARTIFICIAL STORAGE REQUIRED.

We consider that artificial reservoir storage of 2,500,000,000 gallons as fully insuring with a large safety margin the continuous flow into the canal of 40,000,000 gallons daily. The available storage sites will reservoir between 37,500,000,000 and 40,000,000,000 gallons, ample, we consider, to meet as required all the requirements of the City up to a consumption of 150,000,000 gallons daily. There would seem, however, no conclusive economic reason for providing, beyond the first 2,500,000,000 gallons, storage in advance of the time additional consumption requirements would use it The two consecutive years of lowest rainfall in the last 20 years (see Table I) would not require storage carried from the first to the second year.

DIFFERENCE OF SERVICE REQUIRED OF MOUNTAIN WATER STORAGE AND SPRING VALLEY WATER STORAGE.

In this connection, there should not be lost sight of the wide difference of service required from such mountain storage as is proposed, and the reservoir storage of water in the Spring Valley system. The latter has much less annual precipitation to supply it, and series of two and even three consecutive years of low precipitation are common. The natural watershed drainage of these successive dry years, in the summer or dry season, does not supply the evaporation and seepage, and the storage therefore, in addition to the useful consumption, must provide for enormous unavoidable wastes. The safety margin required of the Spring Valley artificial storage is unavoidably much larger than is required of the artificial storage for our proposed supply from the Sierra Nevada Mountains. The former must store from the entire surplus precipitation (the portion not going directly into consumption) of three successive seasons of short precipitation, a quantity of water sufficient to provide the full requirement of the City for not less than two full years' time of the three years, and enormously augmented natural wastage besides, as contrasted with the latter, which need only store from a small fraction of its surplus precipitation of a single season, the water to meet a 50 to 65 per cent. deficiency of natural storage supply for 3½ months. Expressed in ratios the safety requirement of quantity for storage is at least 15 times greater for Spring Valley than for the source of supply here proposed. The available capacities are in this comparative ratio. The Spring Valley, with 70,000,000,000 gallons (including the projected Calaveras Reservoir with dam 183 feet high, 25,000,000,000 gallons) is the equivalent of not more than 5,000,000,000 gallons in the storage of the proposed Giant Gap system. But the latter has an absolute capacity of not less than 37,500,000,000 gallons, or 7½ times the requirement necessary to put it on an equality with the Spring Valley after the latter has developed its entire projected storage capacity.

It follows, as a logical consequence, that the Giant Gap storage capacity is not to be limited to the precipitation of its direct water sheds for a single season, but may be designed to its full structural limits, regardless of precipitation, for the demands on it being so small, excess accumulation during seasons of precipitation exceeding the average would be carried forward, and keep any possible storage capacity full to its limits. The Ice Lakes Reservoir, with its capacity of 26,000,000,000 gallons, exceeding by eight times the average available precipitation of its direct drainage, would, in a term of normal and excess years (the deficiency requirements of which would be met by the other storage reservoirs, ample for such demand) accumulate the entire catchment till completely full, and in such condition, be a reserve storage against two seasons of no precipitation at all, if the possibility of such years can be considered. It is exactly as if in the Spring Valley System, the Peninsular supplies of the San Mateo Reservoirs could, indefinitely into the future, so safely meet demands, that the Calaveras Reservoir (yet to be constructed) could be held an inviolate reserve against a condition of drought never yet known here.


PLAT V
Profile of Bottom of San Francisco Bay
IN LINE OF
Proposed Submerged Conduit
Horizontal Scale 2000 ft to 1 Inch
San Francisco
Alameda Point.
5.25 miles.
Surface of Bay Mean Low Water
Line of 30 feet Depth.
Bay Bottom
Vertical Scale 80 ft to 1 Inch
GIANT GAP WATER SUPPLY

CROSSING THE BAY OF SAN FRANCISCO.

For this we would propose to provide a specially designed submerged conduit.*

Plat V is a profile showing the surface and bottom of the Bay in the vertical plane of the line suggested for the crossing, which is from Alameda Point just north of the old ferry wharf, to San Francisco in Islais Bay, a mile westerly from Hunter's Point. The vertical scale of this profile referred to the horizontal is exaggerated, being 20 times greater.

DESCRIPTION OF BAY BOTTOM AND PLACEMENT OF CONDUIT.

Referring to Plat V, it will be observed that the length of the submerged conduit would be 5.25 miles, that the depth of water over 30 feet at mean low water is 2 miles, and that the maximum depth for .4 mile is 50 feet. The bottom is even and regular. consisting of clayey mud, of fair consistency, as evidenced by its good character for anchor holding. We would propose to trench all the Bay bottom on which the water depths are less than 30 feet and cover the conduit in the trench. The depth of the covering expedient is a matter of opinion, a maximum thickness of 4 feet would seem to us to be sufficient. From all practical points of view this portion of the conduit could be considered as if it were covered in trench on land. So considered it is both absurdly strong and absurdly safe. In depths of water exceeding 30 feet the conduit would rest directly on the bottom.

DESCRIPTION OF CONDUIT.

The suggested conduit is shown in cross section in Fig. 1. It is planned, as shown, to be composed of three pipes, each 42 inches in diameter, disposed parallel horizontally, connected with each other, and with a shell enclosing all three, by radial stiffening flanges, making the structure the equivalent of a metal truss 12.8 feet wide, with 8 vertical members 4.7 feet high. The voids between the pipes and radial flanges would be filled under hydraulic pressure with bituminous rock and asphalt.

ALUMINUM PLATED SHEET STEEL FOR CONDUIT CONSTRUCTION.

The structural metal we propose for the construction is aluminum dipped sheet steel having a finished surface like polished silver. We are informed that the Carnegie Works will shortly put this structural metal on the market as a superior substitute for galvanized iron. If our information proves correct, and the price is not prohibitive, it would be used. Asphalt coating or painting of this metal to protect it from corrosion by either fresh or salt water would be unnecessary. It would be practically indestructible.

MECHANICAL CONSTRUCTION OF CONDUIT.

Should this metal not be possible (No. 6), 2–10 inch sheet steel would be used. In manufacturing, longitudal and transverse seams would be butt jointed and single riveted by straps and the radial flanges. In a shop by the Bay shore the conduit would be put together in some convenient standardized lengths, 200 to 400 or even 500 feet. These lengths would terminate in extra strong machine-faced steel flanges which would also be standardized. For the shell the flanges would be exterior and for the pipes interior, the latter so contrived that while they could be bolted or unbolted from the inside they would not lessen the pipe diameter. The slight angles of the Bay bottom would be provided for by having the gaskets wedge shaped of the taper required. A number of the sections would be provided with manholes, opening from the two side pipes into the middle one, and from the middle pipe through the top of the shell. The outside of the last described manhole would be designed with an extra outside flange of somewhat greater diameter, the purpose of which, as illustrated in Fig. 1, is to enable the attachment by divers of a circular vertical steel tube to serve as a shaft through which convenient access can be had to the interior of the pipes when submerged. The top of the shell of each section would be provided with sufficient number of connection attachments to facilitate the lifting out of place of a length should it become necessary. Temporary shields would hermetically close the ends of the pipes against the ingress of sea water during flotation and submergence. They would be removed only after the shell flanges had been firmly bolted.

THE ESTABLISHMENT OF THE CONDUIT IN PLACE.

The Bay bottom having been first properly prepared to receive the conduit, and piles set to assist its alignment, the lengths are floated and assembled in line. Facilitated by coffer dams, several lengths (includ-

*The invention of Mr. Russell L. Dunn. Patents applied for.

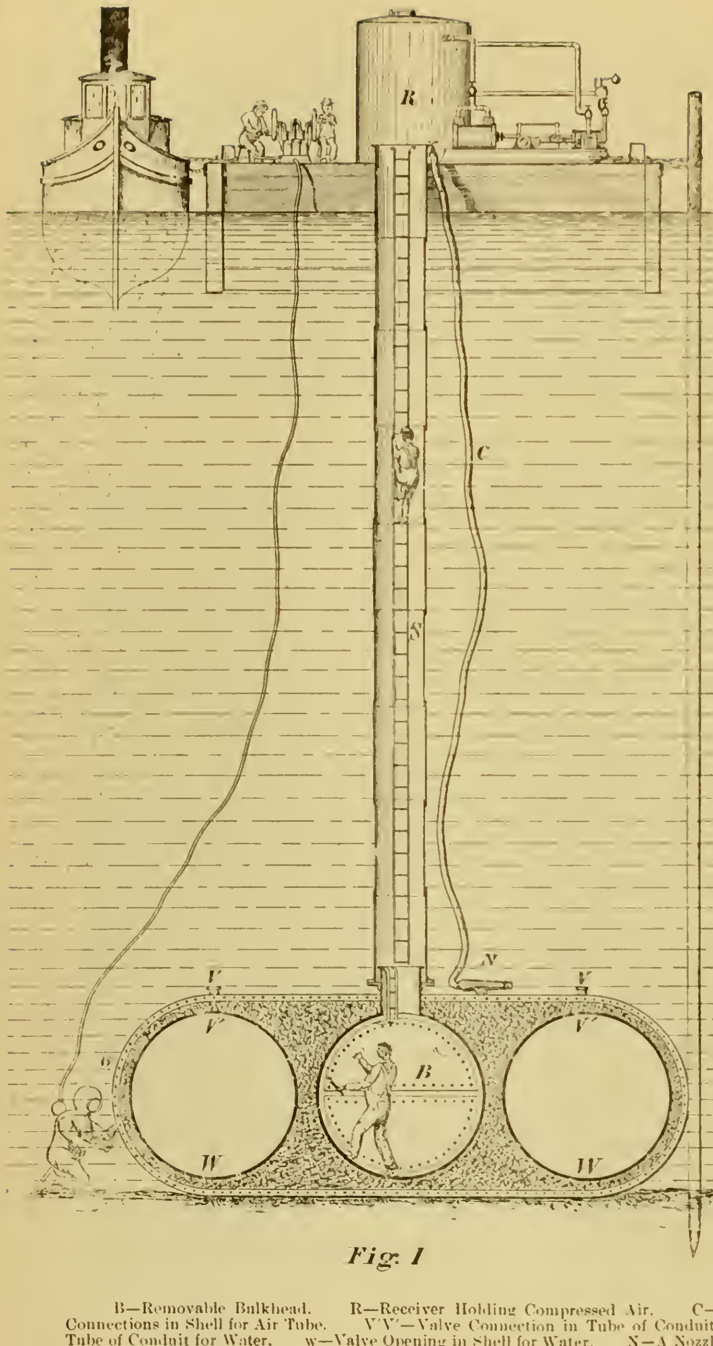


Fig. 1

DETAILS OF METHOD OF SUBMERGENCE OF CONDUIT.

In the submerging and implacing of the successive sections of the conduit compressed air is the source of mechanical power principally employed. Chambers of appropriate cubic content and relative disposition are formed in the tubes by means of the removable bulkheads. Connecting from the outside of the shell to the interior of the tubes within the portion made into a chamber by the shields are two pipes (w-W and V-V′), both with proper connections inside and out. One of these pipes opening on the tube at the bottom (w-W) is for the purpose of permitting the submerging water to flow into and out of the chamber, the other opening on the tube at the top is attached to a flexible tube leading to a scow deck or other platform at the surface where it is connected through a gate and three-way valve with the atmosphere and a compressed air receiver (R . To submerge the section of conduit the connections closing the water pipe (w-W) are removed or opened. Water enters the chamber and the air it displaces passes out through the pipe (V -V) and the flexible tube to the surface, the valve-way to the reservoir being closed. The weight of water overcoming the buoyancy of the section of conduit, the latter sinks beneath the surface. The valve-way to the receiver is then opened and the outlet to the atmosphere closed, thus throwing the compressed air pressure on the water in the chamber. This pressure can be regulated at will and the mass of water in the chamber can be kept stationary, or increased or diminished as necessary, so as to keep the section of the conduit in a desired relative position to another section, to lower it by decreasing the air pressure, thus letting in more water, or to raise it by forcing out all or part of the water by increasing the air pressure. Having several chambers it is practicable to lower a section into place at any desired angle that may be required by the inequalities in the bottom under the water or other conditions of emplacement. When in place finally the tubes are disconnected and the valves closed.

Before submerging, the conduit is kept in approximate position against currents and tides by the piles and appropriately disposed anchors. It is presumed that calm days and slack water would be taken advantage of to submerge the conduit. The piles and anchors would guide the submergence approximately. Exact adjustment to place would be made by using jets of water or compressed air as the motive power to move the conduit laterally and transversely when submerged. From the compressed air receiver, (R), air tubes, (C), would conduct compressed air to the nozzle jets, (N), disposed on the top of the conduit. These could be mounted on a swivel-bearing controlable through a valve and lever by a diver or preferably be fixed pointing in the four directions, longitudally and transversely, and controled by a valve on the operating platform, the diver signaling to the surface the direction of the movement required and the amount of movement till the exact emplacement was effected.

There seems to be no reason why a single operator on the surface with a switchboard of valve levers before him should not be able to submerge and properly place long and heavy sections of conduit. The problem is simply one of power and control. During submergence and placement the section of conduit is a great artificial fish, with artificial bladders (the chambers made by the bulkheads), and with artificial fins (the jet propellers).

B—Removable Bulkhead. R—Receiver Holding Compressed Air. C—Compressed Air Tube. VV—Valve Connections in Shell for Air Tube. V′V′—Valve Connection in Tube of Conduit for Air. WW—Valve Connection in Tube of Conduit for Water. w—Valve Opening in Shell for Water. N—A Nozzle for Fluid Under Pressure (Compressed Air). S—Removable Shaft.

ing at least one with manholes) are bolted together on the surface into sections made convenient for submerging. The sections would then be successively sunk into place and the shell flanges bolted together by divers. Later, at convenience, the pipe flanges would be bolted together from the inside of the pipe, access to them being had through the shaft and manholes already described. The buoyancy of the sections being planned low (see calculation below), and the details of the mode of submergence being contrived therefor, it is practicable to quickly and easily raise a section to the surface should an unforseen contingency require it during construction.

WEIGHTS OF MATERIAL AND BUOYANCY OF CONDUIT.

As planned, the weight per linear foot of the manufactured conduit would approximate,

Metal,	700 lbs.
Bituminous rock and asphalt,	2,265 "
	2,965 lbs.
The weight of displaced water,	3,000 lbs.
Buoyancy per linear foot (the pipe ends being temporarily closed to exclude water),	35 lbs.

THE CONDUIT IN OPERATION.

In use, each of the pipes being of sufficient diameter to deliver 21,000,000 gallons daily under the gravity slope provided, it would be proposed to use only the two outside pipes as water conduits, and to use the middle one as a tunnel for the wires transmitting electrically the power of the water-fall in the mountains.

PRESSURE OF WEIGHT ON CONDUIT ON BAY BOTTOM.

Submerged, the weight of the conduit that would have to be sustained by the bottom of the Bay would be the weight of the fresh water filling the two pipes, less the buoyancy calculated above, and plus (when put in) the weight of the power transmitting wires. Not estimating for the last this net weight would be 1185 pounds.

The area of the flat cross-section of the bottom of the conduit per linear foot of is 8 square feet, whence the pressure weight per square foot would be 148 pounds and per square inch 1.03 pound. This is about a third of the weight per square inch of a man of 170 pounds on his feet.

REMOVING AND REPLACING THE CONDUIT DESCRIBED.

In the event, from some now unforseeable cause, of one, or more, of the pipes becoming broken into, the impaired section would be removed and replaced, in this manner:

1st. The unbroken pipes would be emptied by means that will readily suggest themselves A suction dredge would take out the mud from underneath the flanges. The breach would be closed outside by divers to exclude the entry of sea water while the broken pipe was being emptied of water: the tubular shaft would be attached by divers to the nearest manhole; the shell flange bolts would be removed by divers; tubular cassions of appropriate dimension would be sunk on top of the impaired length and attached to it by the connections provided for that purpose; if the middle pipe was unbroken it would be entered and the electric wires cut and moved out of the impaired length, the pipe flange bolts would be removed, and temporary shields put in place to keep out the sea water when the length was lifted out. (If the middle pipe was broken into, the preceding could not be done till the water was first removed after closing the breach as described above.)

All of the preceding operations would be done together, not successively.

2nd. After the impaired pipes were cleared of water, they would be entered through the manholes, the flange bolts would be removed, the water-tight shields put in place, and the length would then be prepared for removal.

3rd. The cassion being pumped out, the impaired length would be lifted from place and floated to one side.

4th. The length and connecting flanges being standardized, the substituting length would be sunk into place, connected, the shields removed and the conduit would be ready for service again. There is no physical or mechanical obstacle to make the entire operation require more than a few hours.

This facility of removal and replacement is not possible with ball-jointed cast pipe or tubing such as is in submerged service crossing the Bay at Ravenswood, nor in fact are we aware of any submerged conduit ever proposed for this particular kind of service, from which any portion can be practically removed and replaced.

ADVANTAGES OF SUBMERGED CONDUIT PROPOSED.

The style of conduit here proposed resembles in some respects a form of Submerged Railway Tube designed by Sir Edward Reed. For the particular service we have in view here, we consider the construction proposed meets the requirements fully.

1st. Its strength is far in excess of the safety requirements. The pressure heads on the pipes, balanced below the Bay surface, cannot exceed 35 feet or 15 pounds to the square inch. Its pressure weight on the bottom is so low that differences in the material of the bottom that could strain it are almost unconceivable. If such differences do exist they can be equalized by piling and flooring. It would be outside of anchorage ground, but should the unforseen bring up an anchor on it, it would hold it without strain. The drag of an anchor would have against it the resistance of the equivalent of a four member truss 12 feet high by 4 wide, and, it could be added, a resistance somewhat greater than that of a bar of solid steel nearly 15 inches in square cross-section.

2nd. It is accessible for interior examination and repair maintenance through the open middle pipe and connecting manholes.

3rd. Its construction is simple and easily made, and it is so contrived that a length, or a section, can be taken out, and repaired or replaced, without interrupting the use of the conduit for a period of time that the even moderate water storage possible in San Francisco would not be provision against.

4th. It would be as near indestructible from corrosion by sea water as is commercially practicable. Two and one-half miles of galvanized pipes of the Spring Valley system have been under the Bay at Ravenswood for 12 years past and have given no sign of weakening yet. The aluminum plated conduit we propose would be far superior in this respect, and even without the aluminum plating, the outer steel shell and 6 inches of solid bitumen casing the pipes in, we consider perfect protection indefinitely.*

COST CHARGES OF SUPPLY SYSTEM IN OPERATION.

As a preliminary basis for the estimation of the fixed charges of the suggested supply system, we take †$10,000,000 as the amount of investment required. Our proposition for construction hereinafter stated will ask for a less sum.

The fixed cost charges against the supply system (exclusive of a power installation) we estimate as follows:

Interest on $10,000,000 at 3½ per cent.		$350,000
Sinking Fund to write off investment in 40 years .70		70,625
		$420,625
The probable operating expense we estimate :		
Replacement and Repair Fund 1 per cent. on investment	$100,000	
1 Line Superintendent, salary	3,000	
Engineering Department	3,250	
7 Reservoir Keepers	7,700	
8 Canal Tenders	7,500	
14 Pipe Line Tenders	9,000	
Supplies and Incidentals	7,000	137,450
Total cost annual operation		$558,075

*In the construction of the submerged conduit the number and size of the tubes or pipes can be increased. It is practicable to enlarge the open one to a size sufficient to serve as a street-car or railway subway. The two or more conveying water can be enlarged and the bituminous rock filling increased in quantity so that the weight of water and material shall about balance the buoyancy of the open tube. The weight on the base would then be only the distributed weight of the street-car or railway train and the area of base could readily be provided to meet the predetermined pressures. Briefly the open tube has a commercial use additional to the carrying of electric transmission wires. The right to use it as a subway for street and railway purposes and other uses than those expressly stated is reserved.

RUSSELL L. DUNN.

†This does not include the power pipe lines. In all estimates for water supply where pumping by water power is included, the latter is estimated as carrying its own cost charges.

On the basis of a mean daily delivery of 30,000,000 gallons, the cost charges per 1000 gallons are:

Fixed,			
	Interest,	3.19 cents,	
	Sinking Fund,	.64 "	3.83 cents.
Operating Charges,			
	Maintenance,	.91 cents,	
	Operative,	.32 "	1.23 "
	Total,		5.06 cents.

In preparing this estimate, and in fact all estimates on the water supply costs, no account is taken of power development. The water supply is estimated on exactly as if the water power did not exist, and when water power is employed, it is estimated as carrying independently its own cost charges. While in fact the two are practically connected, they are in this presentation commercially considered as distinct entities, so that the facts concerning one are not confused with the facts pertaining to the other.

SAN FRANCISCO PUMPING AND DISTRIBUTING SYSTEM.

The full presentation of our proposition to you necessarily involves some consideration of the probable cost of installation, and probable cost of operation, of the City plant at this end of the supply system.

This City plant would consist of a pumping plant, and of distributing reservoirs and street pipes.

The supply pipe from the mountain source discharging into a receiving reservoir, the pumping plant would be located at the latter in the Potrero.

The capacity of the receiving reservoir is not fixed by any standard. It would seem under the conditions that 20,000,000 or 30,000,000 gallons capacity would be sufficient. The work that would be required of the pumping plant would be the mean daily lift (with 30,000,000 gallons consumption) from intake at 25 feet elevation, of 22,500,000 gallons to reservoirs at 200 feet to 250 feet elevation, 5,000,000 gallons to reservoirs at elevations from 325 to 400 feet, and 2,500,000 to reservoirs at elevations from 475 to 550 feet, or the equivalent of this. For this duty our estimate based on the use of 1700 H. P. transmitted from the water-fall is $59,000 annually. The cost of installation would provide two reserves, one of electric pumps, and a second for some other source of power. We would suggest explosion engines for the second reserve by reason of the rapidity with which they could be put in service in an emergency. The type of pump we would propose to use is the High-Pressure Rotary, recently developed and in most successful operation in Switzerland.

A pipe delivering water is an engine. Like a pump it converts power into useful service. Relative economy is a matter of comparison of costs of the power source. Capital and fuel are merely different forms of stored energy. The pipe consumes the fall of the water and the current interest on capital. The pump consumes fuel, current wages, and current interest on capital. The comparison is simply the current cost of using one engine compared with the current cost of using the other. Both perform the same service. In our particular problem in place of fuel for the pump engine we propose to use the run of the water down hill, which by gravitation would effect the pipe delivery, as the engine operative power for the pump. But as we propose it should be used, the pump engine would not take all the run of the water down hill, and the pump engine as well consumes as interest much less of the stored power of capital. From the surplus of the first alone could be paid the wages and cost of use of capital in the pump engine.

CONSIDERING PUMPING A CITY WATER SUPPLY.

Referring again to the existent prejudice against a City distribution dependent on pumping, we think it has had its inception in a misapprehension of the character of the present Spring Valley system which is commonly reputed to be a gravitation system. This is not strictly accurate to the facts. The Spring Valley system has 8 pump stations, strung in a crooked line over 30 miles long, entending from North Beach in the City to Belmont in San Mateo County. These contain 25 boilers of nearly 4,000 rated H. P., 18 pumping engines of an aggregate capacity of 61,750,000 gallons daily, 14 boiler and engine buildings, employee dwellings and complete appurtenances for an efficient pumping service. They cost in place exclusive of the land they occupy $1,192,000.

The operation of these pumping stations in 1898 cost $80,661 for coal, $45,971 for wages, $5,436 for supplies and $60,000 interest on capital value. Estimating the coal at $5.25 a ton and its efficiency in lifting water as equal to coal consumed in Buffalo in 1899, it would appear that the entire mean daily consumption of the City for that year, 25,000,000 gallons was lifted by the pumps 227 feet. Assuming all the water con-

sumed in the City to be distributed by pumping it from the City Base, the mean lift would be about 277 feet, so that with an actual lift of 227 feet, the Spring Valley system was, in 1898, 85.5 per cent. a pumping system and 14.5 per cent. a gravitation system. The location of the pumping was of no consequence; what became of the water after it was pumped, whether it went higher as evaporation, or downward as seepage, or became useful as consumption, mattered not; the essence of the pumping operation was, that consumers paid for pumping 85.5 per cent. of the quantity of water they consumed.

With the actual conditions as described, the City has been supplied for years past so largely by pumping, that a comparison of the system of supply you have with the system we offer, is not a comparison of a gravitation system with a pumping system but a comparison between a pumping system of 8 scattered stations costing for installation $1,192,000 and for annual operation $192,000, with a pumping system of one plant costing for installation not more than $450,000, and for annual operation $59,000.

CITY DISTRIBUTION.

For the City distribution, there are a sufficient number of appropriate sites for reservoirs. We are prepared to designate a site, and to submit plans and estimates for the constructing in it of a reservoir of any desired capacity up to 200,000,000 gallons.

We have made an estimate of the probable cost of a street distributing system of 400 miles, nothing less than 6" diameter where fire hydrants would take out, larger mains and branches than now in, and steel tubing for all but the larger diameters. Including the necessary reservoirs our estimate is less than $4,000,000. We have used that figure in the preparation of Table VI.

COMPARATIVE COST CHARGES OF WATER.

San Francisco and Buffalo are cities of approximately equal population. The water supply system of Buffalo is owned by the municipality and operated under the management of the Board of Public Works. The water works system is entirely pumping. The figures given for costs of operation are compiled from the Official Report for 1899. We introduce them here to show that in a City of the same class as San Francisco, municipal ownership and management successfully supply its consumers efficiently and at a low cost, and incidentally to have a direct comparison of the respective costs of common items of service there and here.

In addition to the segregated cost charges of the Spring Valley system for 1898, we have included totals of fixed charges a· perating charges 1884 and 1891, (the figures are prepared from the Official Report of the Spring Valley Company to the City for 1898, Municipal Report 1898–99, page 22 *et seq.*); also, in order to get a common basis of comparison with the probable cost charges of our suggested system, we have estimated and tabled the Spring Valley system as it would be, supplying under existing conditions of ownership, 30,000,000 gallons daily; and have made a second estimation on the basis of the system, as if acquired by the City and supplying 30,000,000 gallons daily, taking as the investment cost to the City now, the least that can be unreasonably imagined, namely, the face of the 1st, 2nd and 3rd Mortgage Bonds, $12,775,000. Finally, we recapitulate the figures of our estimation of the operating costs of our suggested system, and add the fixed charges there would be against it, the latter being not an estimation, but absolute, as we will contract construction of the system within the figures of investment cost they stand for.

In this connection we ask your consideration for the comparisons that constitute so large a part of the presentation of our proposition. We do not present them in any sense as criticisms, for indeed they are not, but we realize that the most intelligible commercial conception we can give you of our proposition is only possible through comparison with the Spring Valley system which you have, and which you know and understand. Sentiment has little place in considering a water supply problem. It is strictly a business matter, dealing with an indispensable necessity of life. Yet we know, that the vast mass of human energy represented by the capital investment of Spring Valley, the great commercial and legal abilities that have financed it, the high engineering skill represented in its monuments, the service it has been to the City, are all factors that have, and should have, your consideration. On even cost figures of acquisition, or on measurably near figures, the Spring Valley system that is, should be acquired, rather than another system that has yet to be. We realize, therefore, that it is up to us, to demonstrate conclusively, not only the positive, as to the absolute commercial merit and desirability of our proposition for acceptance by the City, but the negative, as well, even more conclusively, as to the undesirability of the Spring Valley system. It is up to us to do this, but if in doing it, we have demonstrated the commercial impossibility of the Spring Valley system for acceptance by the City, the business of the City is then with that proposition which is commercially possible.

TABLE VI.

* Estimated.

Cost charges paid (in cents) per 1000 gallons of water delivered to consumers.

System.	Year.	Population.	Daily Consumption, Gallons.	FIXED CHARGES. Interest.	Sinking Fund.	Total.	OPERATING EXPENSES. Taxes other than City.	Replacement and Maintenance.	Supply System.	PUMPING. Fuel.	Labor, etc.	Total.	City Distribution.	Office and Salaries.	Total.	Total all Cost Charges.	Portion of Total Rates Paid Private Consumers.	Portion of Total Rates Paid by City.	Cost per 1000 Gallons Paid by Rate-payers.	Cost per 1000 Gallons Paid by City.
				cents.	cents.	cents.	cents.	cents.	cents.	cents.	cents.	cents.	cents.	cents.	cents.		dollars.	dollars.	cents.	cents.
Buffalo . . .	1899	352,000	92,363,000	.48	.10	.58		.22		.14	.30	.44	.15	.09	.90	1.48	$707,000			none.
Buffalo. Interest at 3½ on total valuation all other expenses at San Francisco rates . . .	1899	352,000	92,363,000	.96	.19	1.15		.24		.56	.38	.94	.16	.10	1.44	2.59		none.		none.
Spring Valley. Deducting City taxes in order to make comparison on even terms with above .	1884	*258,000	17,400,000	10.50		10.50	.52								6.28	16.78	$1.190,613	$ 82,858	15.60	1.18
	1891	*303,000	21,500,000	14.90		14.90	.76								5.56	20.46	1,516,232	88,565	19.34	1.12
	1898	*333,000	24,000,000	14.90		14.90	1.10	.40	.43	.91	.59	1.50	.98	1.83	6.24	21.14	1,490,921	245,165	18.15	2.99
Spring Valley, Calaveras supply $7,000,000 added . . .	1908	*390,000	30,000,000	15.30		15.30	1.56								6.70	22.00	$2,409,000			
Spring Valley, under City ownership at cost of 1st, 2d, and 3d mortgage now issued, with Calaveras supply added of $7,000,000. Total cost, $19,775,000 . .				6.33	1.27	7.60								.51	3.82	11.42	$1,250,000			
Giant Gap . .	1908	*390,000	30,000,000	4.66	.93	.59		1.03	.32	.18	.20	.38	.34	.51	2.58	8.17	$894,000			

THE SPRING VALLEY FIGURES.

The cost charges have all been calculated in cents per 1000 gallons as being the units of value and quantity closest to consumers. 100 cubic feet is equal to 748 gallons.

In the Spring Valley figures a considerable increase in the interest cost charge per 1000 gallons between 1884 and 1891 is notable. From 1891 to 1898 this cost charge would not appear to have increased, but the equality is the averaging down effect of the reduction of the rate of interest on the stock from 6 per cent. to 5 per cent., and of the issue of 3rd mortgage bonds which bear 4 per cent. interest, while 6 per cent. is paid on 1st mortgage bonds.

On even terms of interest the increase in cost charges was more than the 1.14 cents shown in the table. At the same interest rate on investment in 1898 as in 1891, the interest cost charge per 1000 gallons would have been 15.7 cents, an .8 cent increase, making a total increase per 1000 gallons of 1.44 cents. The meaning of which is that it took more of the dollars of investment between 1891 and 1898 to provide 1000 gallons of water to a consumer than it did in 1891, and further that the addition to water production was accomplished at cost charges so much increased, that distributed at consumers' rates there was an actual loss to the Company. This condition is not, however, exceptional in the operation of the Spring Valley system.

Referring to the proportion of the total cost charges carried respectively by private consumers in rates directly, and by the same private consumers in taxes indirectly, comparing 1891 with 1898, it will be noted that in 1898, the consumers, in taxes indirectly, paid 1.9 cents more of the cost charges of 1000 gallons than they did in 1891—this increase carrying all of the total increase of cost charges between the two years, 1.14 cents, and the decrease of .76 cent of the total cost charges paid by consumers.

Measuring by the actual conditions as developed by past Spring Valley operation, it would seem that the commercial limit of expansion of the supply system of Spring Valley had been reached. The interest rate cannot go much lower with so much of it carried by bonds for which there is no provision for payment made. Operating cost charges are increasing instead of decreasing. There is no reduction apparently possible in present cost charges, and additional deliveries, involving cumulating additional investment to supply them, average up the cost charges instead of averaging them down.

The tabled figures illustrate commercially what the result of this averaging upward of cost charges will amount to when the consumption of Spring Valley requires the delivery of 30,000,000 gallons daily. The physical conditions practically compel, to provide the additional delivery, the construction of the Calaveras reservoir and pipe conduit. The net investment required for this construction has been estimated at $7,000,000 (Municipal Reports 1876–77, p. 822–23), which sum we add to the present investment to determine the fixed charges per 1000 gallons. Operative expenses we increase by an estimate of taxation on the new plant, it being all located outside the City. That the system with this construction will provide more than 30,000,000 gallons daily is of no consequence. Interest charges are fixed and are not postponed. Taking the same rate of interest paid in 1898 and allowing $40,000 for the tax on the added $7,000,000, and the same rate of operating charge, the total cost charge per 1000 gallons for a 30,000,000 gallons daily delivery would be 22 cents. As noted in Table V the Engineer of the Spring Valley estimates the net investment acquired as $10,677,000. If this be taken the fixed cost charges per 1000 gallons would be increased additionally $.0167, making the total cost charge 23.67 cents. For the purpose of Table VI we have preferred to take the estimate prepared by the City's Engineers though lower than estimated by the Company's Engineer now.

Considering, for the purpose of comparison under even conditions, that the Spring Valley Works be acquired now by the City at the face of outstanding bonds, $12,775,000, the stock value being wiped out by the transfer, and that then, there be added the Calaveras supply at its estimated cost of $7,000,000, consumers, thousand in water rates, would pay fixed charges of 7.60 cents per ~~hundred~~ gallons and operative costs as before, except that taxation would be eliminated and office and salaries would be the same as estimated for Giant Gap. The total of these fixed and operative charges would be 11.42 cents per 1000 gallons as contrasted with 8.17 cents per 1000 gallons, the total of cost charges estimated against the proposed Giant Gap water supply. Using the Company's estimate of $10,677,000 for the cost of the additions the cost charge per 1000 gallons would be 12.83 cents.

The consumers of the City would then have to pay for the Spring Valley supply from $975 to $1400 a day more than they would have to pay for the same supply from Giant Gap.

COMPARISON COST CHARGES—PROPOSED GIANT GAP WORKS WITH BUFFALO WORKS.

The cost charges of our proposed system can stand comparison with even the exceptionally high standard of the Buffalo City system of water works. The estimated value of the Buffalo works is $9,000,000 as compared with not more than $14,600,000 estimated investment required for our proposed San Francisco works, including the City Pumping and Distributing Plant, but excluding the Power Development and Transmission Plant. The former has a much more costly pumping plant than would be required here, between one-fourth and a third more pipe distribution, and is at the disadvantage in cost of being a village system which has required expansion long before its plant required replacement. The extra investment for this City would be the cost of the supply plant extending from a source over 200 miles distant. (The Ice Lakes Reservoir by the line of its water flow would be 216 miles distant). There is no corresponding element to this in the Buffalo works, the latter being the equivalent of the pumping and street distributing plant only. Directly comparing these equivalents, our outside estimate for San Francisco works of $4,600,000 is in proportion to the Buffalo works valued at $9,000,000. The San Francisco works are planned for half the consumption delivered to twice the elevation as compared with the Buffalo works. Buffalo has written off $5,200,000 of the estimated value of her works and only has interest and sinking fuud charge to pay on $3,800,000, as compared with $14,600,000 estimated for San Francisco. Both cities providing for writing off the capital investment, fixed charges will ultimately be eliminated and the economical difference between them will be in operative cost charges alone.

Replacement and maintenance in Buffalo cost .22 cent per 1000 gallons, at San Francisco labor rates .24 cent; reduced to the San Francisco water consumption of 30,000,000 gallons daily would be .74 cent as compared with 1.03 cents, the estimate for our proposed San Francisco works. The ratio between the two approximates fairly the ratio between the respective investments in plant.

The pumping cost charges at San Francisco would be materially less than they are at Buffalo by reason of cheapness of the water power available here. Applying the same mode of comparison made above, the cost charge per 1000 gallons in Buffalo, distributed to the San Francisco mean elevation of delivery (277 feet above the Bay level) would be nearly 2½ times the cost charge we estimate here. Of the San Francisco lift, however, 25 feet would be carried by the supply system and the actual ratio between the pumping costs would be about as 1 is to 2.2.

CURRENT CONSUMERS' RATES.

In Buffalo metre rates to manufacturers are about 2 cents per 1000 gallons, and house rates are fixed to correspond as near as may be to a rate of 5 cents per 1000 gallons. Extensions of the system are for the most part carried by receipts. From the statement from 1899 it would appear that the metre rate of 2 cents is about 15 per cent. above the total of cost charges.

The margin of 15 per cent. over cost charges would seem unnecessarily high for the proposed works here. Estimating at 7½ per cent margin, with cost charges of 8.17 cents per 1000 gallons, flat metre rates could be 8¾ cents, and house rates could be based on a 12-cent metre rate. By the schedule of metre rates in force in San Francisco under the ordinance of 1898, the metre rates to consumers from 40,000 cubic feet monthly, upward, were such that they received water at less than its cost, the lowest rate being 4⅓ cents per 1000 gallons less. Whatever the aggregate of the loss so made, it must have been made good by the other rate payers. The highest metre rates were 37 cents per 1000 gallons and house rates, though no basis is stated, are presumedly on a higher basis than the highest meter rates.

ESTIMATED FUTURE RATES.

The basis of rates being cost charges, and the fixed charges of the initial investment being equalized, as we have assumed, over 40 years, only such reduction in rates could be made, as reduction in operative cost charges would correspond to. These could amount to as much as 12½ per cent. if the full capital charge for extensions should be otherwise provided. We have in considering extensions indicated conditions as probable which would permit of these small reductions of operative cost charges carrying the cost of the extension or at least the larger portion of such cost. At the end of 40 years writing off of the fixed charges would enable rates to be based on operative cost charges not exceeding 2½ cents per 1000 gallons and possibly as low as 2 cents.

WATER POWER DEVELOPMENT AND ELECTRICAL TRANSMISSION.

The Upper Pipe Line has already been described as it would be provided merely for the carrying of water from the Elfland Reservoir to the Orange Reservoir.

Plat IV is a profile of this line. It will be noted that the hydraulic grade lines show only low hydraulic pressure heads, though the total difference in level between the two reservoirs is over 1200 feet.

The utilization of this pipe to develop power from the fall of the water is not practicable coincident with its use to deliver the required quantity of water. Its size and strength are not sufficient, and free discharge means the use of all the power from the fall in balancing the friction resistance of the pipe to the flow.

WATER POWER DEVELOPMENT.

While your Resolution No. 257 does not contemplate the submission to the City of a water-power project, the fact that the use of power is an essential element of the suggested system of works, naturally carries with it a consideration of the possible sources of power, with the end in view, that other conditions being equal, the cheapest power shall be the basis of the projected operation of the works. Tables III and IV were prepared principally for the purpose of this determination, and comparative costs have also been calculated for the operation of the suggested City Distribution Pumping with the three common power sources. The development from these investigations, that the water power of the fall between the Elfland and Orange Reservoirs was the cheapest available source of power for the proposed use, is the explanation of the reference we make to it.

PLANT FOR POWER DEVELOPMENT.

For the development of the power from the daily supply of 30,000,000 to 50,000,000 gallons, we suggest two pipe lines, each 38" diameter, made of thicknesses of steel proportioned to be 2½ times the strength required to sustain the static (not hydraulic) pressures. Either of the pipes with free discharge would carry the entire consumption of the City. Each of these lines is to be divided into two sections at Newcastle, the sections being nearly equal in length, and having equal outlet pressure heads of about 600 feet. There would then be installed, two similar power-generating stations, one at Newcastle and the other at Orange Reservoir. This arrangement is economical of steel in pipe construction, provides manageable heads of water, and dividing the power plants and pipe conduits into practically four units, eliminates the risk of the consequences of possible accidents in operation.

AMOUNT OF AVAILABLE POWER WITH 38,000,000 GALLONS DAILY FLOW.

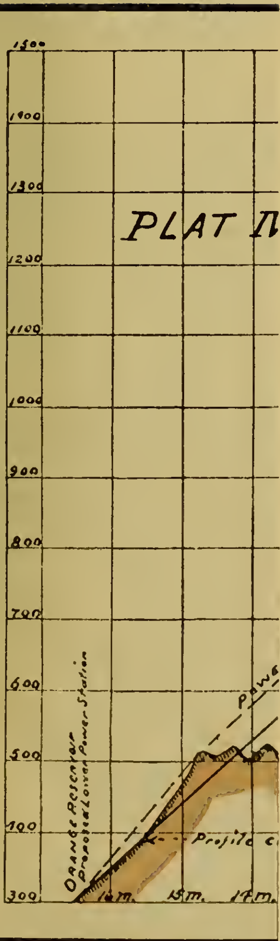
The power development with 38,000,000 gallons daily would be 6400 H. P. from the generators, of which we are advised 80 per cent.,* 5000 in round numbers, could be guaranteed as utilizable for work after transmission 110 to 120 miles. The cost for this power delivered at San Francisco is 3.7 cents per 24-hour H. P., including in the estimate of cost 3½ per cent. interest on investment in pipes and for generating plant, 1 per cent. for maintenance and replacements of pipes and 4 per cent. for station and line, .7 per cent. for sinking fund to write off investment in 40 years, and current operating expenses of the generating station and line.

UTILIZATION OF 5000 H. P.

This 5,000 H. P. (3730 Kw), would be an installation that we suggest the City could utilize as follows:

For pumping the City Water Distribution, 24 hour H. P	1700
For the electric lighting of the Streets, Parks, and Public Buildings, 3,000 10 hour H. P. equivalent with 15 per cent. Line Loss to, in 24 hour H. P	1500
For heating and cooking in the Public Buildings and Institutions, Schools, Hospitals, Almshouse and Jails (the equivalent of about 4,000 tons of coal) with Line Loss allowance, in 24 hour H. P.	600
Pumping Sewerage and other uses, in 24 hour H. P..	1200
Total Public Utilities	5000

* Guarantee of a responsible Electric Manufacturing Co.


1500
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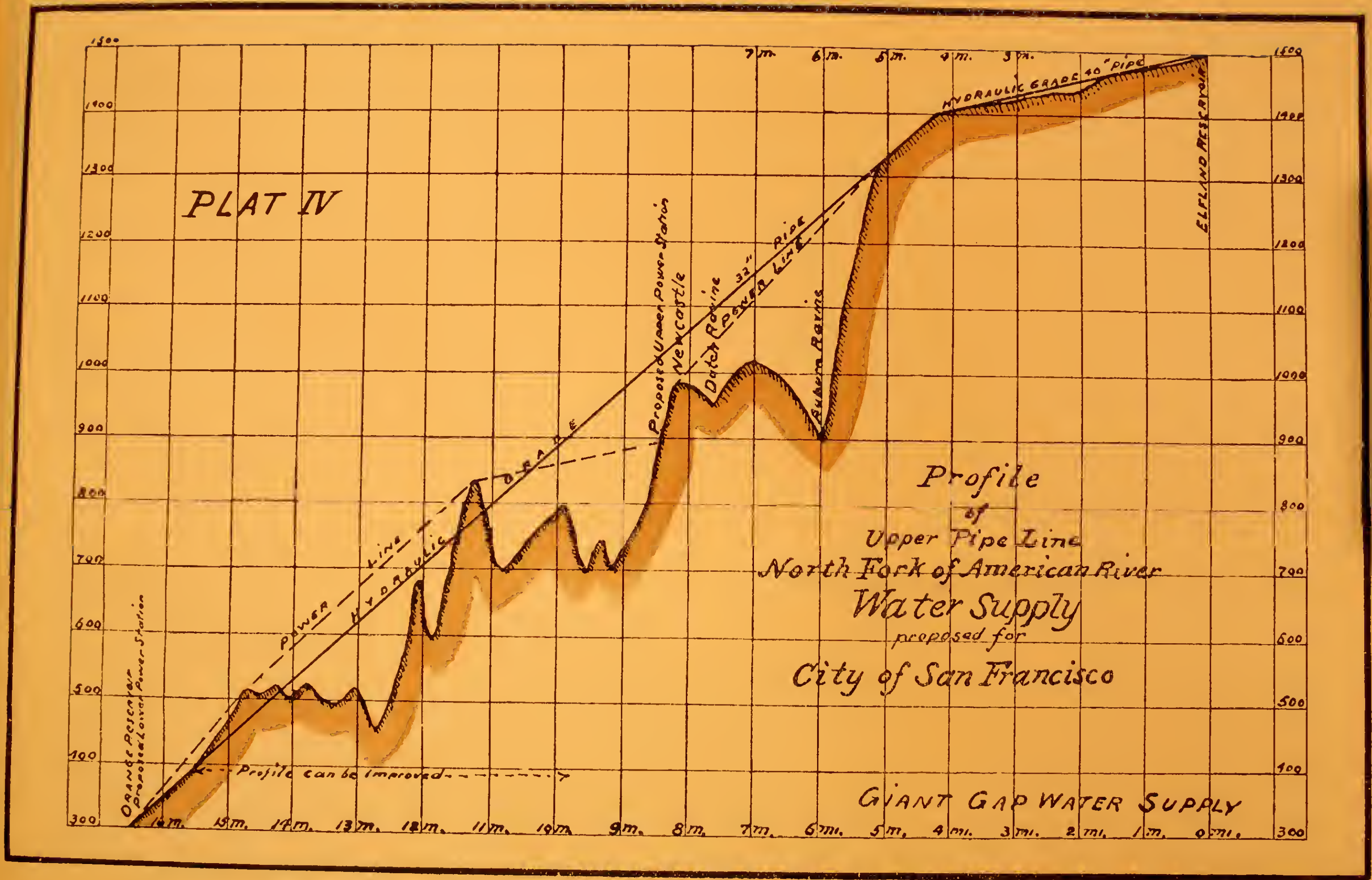
ORANGE RESERVOIR
Proposed Lower Power Station
14m.
15m.
17m.


PLAT IV
Profile
of
Upper Pipe Line
North Fork of American River
Water Supply
proposed for
City of San Francisco
GIANT GAP WATER SUPPLY
HYDRAULIC GRADE 40" PIPE
ELFLAND RESERVOIR
POWER LINE
HYDRAULIC GRADE
32" PIPE
POWER LINE
Proposed Upper Power Station
Newcastle
Dutch Ravine
Auburn Ravine
Orange Reservoir
Proposed Lower Power Station
Profile can be improved
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1400
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16 m. 15 m. 14 m. 13 m. 12 m. 11 m. 10 m. 9 m. 8 m. 7 m. 6 mi. 5 m. 4 mi. 3 mi. 2 mi. 1 m. 0 mi.
7 m. 6 m. 5 m. 4 m. 3 m.

WHAT THE CITY NOW PAYS FOR LIGHT AND HEAT.

The City now pays for Lights (1898–99)....	$312,790 98
The public coal bill is (1898–99).........	27,796.50
Total...	$340,587.48

COST OF PUBLIC LIGHTING, HEATING AND COOKING BY WATER POWER.

The cost of the electric lighting, heating and cooking by our proposed system (estimating 80 line men employed), exclusive of interest, etc., on City distributing lines, would be about.. ....$150,000.00

Resulting in a net annual saving to the City, which should be credited against the cost of operation of the water works, of...... ....$190,500.00

POWER FROM 100,000,000 GALLONS DAILY.

But there is no reason why the City should not at once develop all the water power it has and derive therefrom a commercial revenue. The water otherwise wastes its energy flowing in its natural channels. The canal line having to be constructed for the water supply service to carry 100,000,000 gallons daily, the additional installation for power development from this quantity, would only require adding to the mountain reservoir capacity, more and larger pipes in the Upper Pipe Line, additional generators and more lines of wire. There could be generated from 100,000,000 gallons flow daily, transmitted and delivered at San Francisco, available there for use, 13,000 24 hour H. P. (9,700 24 hour Kw).

Deducting for the Public Utilities that we have enumerated above 5,000 H. P., there remains 8,000 24 hour H P. (5,968 24 hour Kw), which we believe would be readily salable in the City for $7.00 a 24 hour H. P. per month (this would be $.0131 per Kw hour), and at that rate would produce an annual revenue to the City of $672,000, which should be credited against the cost of operation of the water works.

A POSSIBLE BALANCE SHEET.

The Balance Sheet of the City and water consumers on the annual operation of the **GIANT GAP WATER SUPPLY SYSTEM** and its Water Power would then read something like this:

THE CITY OF SAN FRANCISCO AND PEOPLE,

DR.

To annual cost charges Water Supply		$ 895,000
To annual cost charges, Public Electric Lighting, Heating and Cooking		150,000
To annual cost charges for additional 8,000 H. P.		108,000
		$1,153,000

CR.

By present cost of Water paid by City and consumers to Spring Valley Company	$1,800,000	
By present cost of Public Lighting (1898–99)	312,790	
By present cost of Fuel	27,796	
By income from 8,000 H. P. at $7.00 per month	672,000	
	$2,812,586	
Net annual profit over all operative cost charges, replacements and sinking funds and interest on investments		**$1,659,586**

WHAT THE BALANCE SHEET FIGURES MEAN.

The income from the power, $672,000, is certainly a very considerable underestimate. Electrical power manufactured from fuel in San Francisco costs at least $.0212 per Kw hour. Our estimate of income is based on a sale at $.0131 per Kw hour. The mere displacing of the fuel by the water power would make a sale price at least $.02 per Kw hour. The increase in income at this last price, estimating the year 300 days, would be $480,000. The present cost of water paid by the City and consumers is $1,800,000 for a mean daily supply of 25,400,000 gallons. If the daily supply be 30,000,000 as estimated for Giant Gap the cost to the consumers and the City would be $2,400,000 annually or $600,000 more than we have estimated (See Table VI). We have therefore reduced the reasonably probable credits by $1,080,000 annually in making

the balance sheet. Our purpose in this was to eliminate differences of opinion which would increase the estimate we make of operative costs, the *debit* side of the balance sheet, and to be inclusive of unestimated City power distribution costs, the amount of which would be dependent somewhat on the extent of the use that the City would make of underground conduits already in place in which the City has reserved rights for its own installation of line plant.

Probable annual credits being thus underestimated $1,080,000, the increase of debits could become an equal sum before the profit balance of the balance sheet, $1,650,000 annually, would be diminished. We say, therefore, that the stated net annual profit sum, $1,650,000, is a safe figure to reason from.

Commercially this profit sum of $1,650,000 can be considered as being the equivalent of a DIVIDEND paid on the "Common Stock" of an industrial corporation or trust, after all operative and fixed charges and the fixed per cent. of dividend on the preferred stock are paid. So considered, this amount of annual dividend would give $27,500,000 of market value to the common stock that paid it, (taking 6 per cent. as a rate that would maintain such a stock at par).

That is to say, the City of San Francisco operating our proposed system of works, paying from the sales returns, all operative costs and 3½ per cent. of interest on the bonds representing all the money actually invested (the bonds would be the equivalent of preferred stock) would pay to its people (directly and indirectly) the equivalent of 6 per cent. on $27,500,000 of common stock, which in this proposition would unquestionably be *water*.

Commercially, from another point of view, the flat investment point, the $27,500,000 capitalization of the net annual profit means, that in addition to the sum we estimate would be required for the works, there could be additional amounts added up to a total of $27,500,000 additional, and what we offer and propose would still be good business for the City.

This explanation is given here to the more clearly fix your attention to the decisive business feature, the money saving and money earning power, of our proposition. No difference of opinion as to a construction detail should befog this practical point of view. Calculate the plausible differences of construction detail, consider them as installation costs increasing our estimate, and compare them with the $27,500,000 credit balance of surplus capital the City would open its construction account with. It is a coincidence that this credit balance is about the same in amount as the investment capital sum of the Spring Valley Company at this time. So far as the City and water consumers are concerned the latter sum is in the debit column, not the credit.

ADDITIONAL POWER DEVELOPMENT.

The preceding has considered only the power development after diversion of the water from the river. We are safely within the possibilities in stating the ultimate development and delivery at points of use of power possible economically, as being 20,000 H. P. additional to the amount above stated. This additional amount would be developed by the flowing water in the tributaries to the two main streams in the watershed, supplemented in summer by the reservoir flow to equalize the development throughout the year The power development pipes would have their intake ends at about 4000 feet elevation and the power stations would be on the banks of the main streams. The rise from Euchre Bar of the South Fork of the North Fork is comparatively light, only about 1000 feet in 20 miles. At 4000 feet elevation there is little or no danger of interruption to the flow of water into the pipes from either snow or ice. The power plants would all be below 3000 feet in elevation.

The physical conditions are exceptionally favorable to this additional power development. As already noted, by far the larger portion of the area of the watershed is over 4000 feet in elevation, so that the major part of the precipitation can be utilized. Referring to the map, and the Colfax and Truckee Topographical Sheets of the U. S. Geological Survey, you will note that the distances from the contour line of 4000 feet elevation to the main streams are comparatively short. The pipe lines for power will thus be short and comparatively inexpensive. The transmitting wires have a direct route free from heavy snow fall down the river cañon and along the line of canal to the power consuming markets.

THE POWER DEVELOPMENT THE CHEAPEST IN THE WORLD.

At $.037 per 24-hour H. P., the electric power we propose the development of, would be the cheapest in the world. The cost per H. P. hour would be $.00154 or something less than one sixth of one cent. The daily newspapers have recently commented extendedly on successful power development in the Italian

Alps, where the cost is stated to be one-fourth of one cent per H. P. hour. It will be noted that even this remarkable cheapness is possible of being improved on in our proposed works. And the additional amount of possible power development referred to in the preceding paragraph could be produced at a cost it would seem even less, so exceptional is the tripple combination of the exceptionally favorable physical conditions with two associated utilities—water supply and electric power. [If the cost stated $.0025 per H. P. hour referred to electrical H. P., Kilowatts, the cost of the equivalent instead of being $.00154 would be $.00206 per Kw or electrical H. P., say 20 per cent. less than the cost in the Italian Alps.]

WATER WORKS CONSTRUCTION GENERALLY.

The suggestion of a pipe conduit of 35,000,000 gallons daily flow capacity by gravitation alone as the initial unit of installation, has been made after a thorough consideration of the increase of water consumption in the City during the last 25 years, and of what seems to us, its most probable rate of increase in the next 20 years (making some allowance for a per capita increase inevitable with the much lower cost charges). We have estimated for larger units of initial installation, a 45,000,000-gallon daily flow capacity in particular, but we find that for absolute economy of cost charges of the water consumption, now and in the future, the balance of commercial profit is with the initial installation unit we have suggested.

We believe that the capacity of conduit we suggest not only satisfies the conditions but improves them, for from the initial installation each added increment of increased consumption brings with it a decrease in cost charges instead of simply, even cost charges. The minor details are not essential elements, though in a work of so great magnitude they affect the cost of initial installation. Though in the submerged conduit we have proposed to use 2–10 inch thick steel, it has been in deference to the popular feeling that such conduits ought to be extra strong rather than that there was a sufficient technical reason for it. We consider that the thickness of steel for the pipes, protected as they would be by 6 inches of bituminous rock and asphalt and the thick outer shell, could be reduced, and a material saving of cost be made. It would also seem desirable to substitute for the proposed tunnels under Carquinez and Oakland Harbor, submerged conduits, as described for the crossing of San Francisco Bay.

THE WORKS WE WOULD PROPOSE TO CONTRACT TO CONSTRUCT.

The following are the general structural specifications to which we would propose to conform as the basis of our offer :

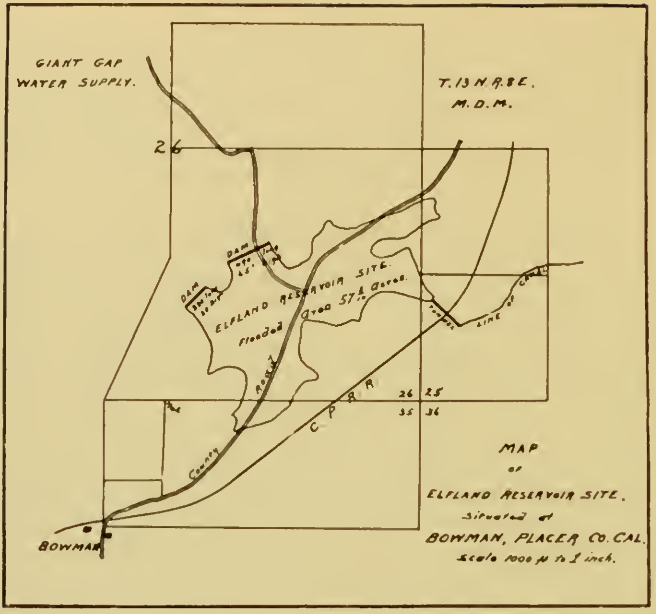
1. Mountain Reservoirs—Palisade Lake, capacity for storage 4,000,000,000 gallons. Dam to be of rough granite masonry 70 feet high; substantial outlet gate-well, gate, outlet pipe through masonry and waste-wier through top of dam. Dwelling for keeper.

Ice Lakes—Capacity for storage 26,000,000,000 gallons. Dam, rough granite masonry 100 feet high; outlet gate-well, gate, outlet pipe through masonry, and waste-wier through top of dam. Dwelling for keeper. Reconstruction of road around the flooded area.

2. Diversion Dam at Euchre Bar—Top 100 feet long, bottom 40 feet, height 35 feet; material, rough stone masonry, cement mortar; crest of dam protected by heavy steel plate.

3. Headworks of Canal—Masonry forebay, screen, timber gates, cut 112 feet long 12 feet deep through solid rock, covered with arched masonry, sand box. Dwelling-house for keeper.

4. Canal Line from Euchre Bar to Elfland Reservoir, 51.35 miles long, fall 11 to 8 feet to mile—Ditch excavation 8′ bottom width, 10′ to 12′ top, 4 feet deep cut in grade 12 feet wide. Bank sloped to be stable, lower side cleared and broken so excavated spoil will bind into it. Flume 6 feet wide, 5 feet high, material of sides and bottom heart sugar pine 1½ inches thick; mountain lumber for construction; flume generally on solid rock bed, exceptionally on trestle bents. All ravine drainage passed under trestles or over canal in boxes; ditch and flume to have a sufficient number of waste outlets. Canal to be fenced where necessary. Dry protecting ditches on bank upper side flumes; three tunnels aggregating 400 feet, through which flume passes; two tunnels 1500 feet, brick lined. 5 dwellings for ditch tenders. The daily capacity of the canal shall be a flow of 100,000,000 gallons. (The entire canal line is surveyed and staked, grade broken, and two tunnels built in Giant Gap.)



5. Elfland Reservoir—Capacity 500,000,000 gallons. Dam of earth; top length 490 feet, height 65 feet; brick outlet gate-well; tunnel outlet from well, screens, gate, etc. Dwelling for keeper.

6. Upper Pipe Line—Constructed as herein described for water power development from flow of 100,000,000 gallons daily, with four pipe lines each 45 inches in diameter. Pipe to have longitudal seam double riveted, to be buried in trench, top 2 feet below the surface, and provided with outlet gates, air valves and manholes.

7. Power Station at Newcastle—Fire proof building, five receivers, five independent plants of water-wheels and generators (one to be reserve), each plant 1500 Kw. Concrete receiving tank for water.

8. Power Station at Orange Reservoir—Installation similar to Newcastle.

9. Orange Reservoir—Capacity, Est. 200,000 gallons. Dam 600, length on top; height, Est. 40 feet. Appurtenances similar to Elfland Reservoir. (Not surveyed.)

10. Lower Pipe Line—61¼" diameter. No. 9 sheet steel 75,000 lbs. tensile strength. Seams butt-jointed. Longitudal seam double-riveted to flat strap—transverse seam, a T strap single-riveted. Pipe dipped in asphalt laid in trench with longitudal seam on top, covered 3 feet deep.

11. Crossing of Sacramento River—Alternative construction: 1. Conduit similar to conduit proposed for crossing San Francisco Bay. This conduit would be submerged and covered in a trench in the river botton; or, 2, Tunnel, with pipe carried through it; maximum capacity of flow 60,000,000 gallons.

12. Crossing of Tule Basin—1. Pipe buried in trench; or, 2, Pipe carried on trestle (We would suggest the former as preferable).

13. Benicia Tunnel—Length about 3100 feet, built just below hydraulic grade line. Concrete lined 7.5 feet clear diameter. Pipe connections made at both ends. Capacity 100,000,000 gallons.

14. Carquinez Tunnel—About 4000 feet long. To be built under the bottom of the Straits at about 160 feet depth from shafts at each end. Tunnel to be concrete-lined and to have a slight grade from the Benicia end. Shafts to be concrete walled. Pipe to be connected with the shaft at both ends. Electric power conduits to be placed. Electric pumps, pump shaft and connections at Vallona end in place to clear water from tunnel if required. 2. Or an alternative construction employing the style of submerged conduit proposed for crossing the Bay.

15. El Cierbo Tunnel—About 3000 feet long. Construction similar to Benicia.

16. 1—Oakland Estuary Tunnel—About 2,200 feet long, about 75 feet below low tide level. To be bored from shafts at both ends, descending grade to Oakland end. Tunnel shafts 7½ feet diameter inside. Lining of tunnel and shafts concrete or brick; or, 2—Submerged conduit as described, the dredging to place it to be made to 30 feet depth.

17. Crossing Bay of San Francisco—About 27,500 feet, submerged conduit constructed and placed as described.

18. Gates 61½" diameter to be placed, with proper connection : 4, two (2) at each end of Sacramento River crossing; 4, two (2) each in main and in loop branches at Vanden; 4, two (2) at each end of Benicia Tunnel; 2 at Benicia end of Carquinez Tunnel; 2 at outlet end El Cierbo Tunnel; 2 at Oakland end of Oakland Estuary Tunnel. The short lengths of pipe conduit intervening between the Carquinez Tunnel and El Cierbo Tunnel and between the outlet of the Oakland Tunnel and inlet to the submerged conduit about 8000 feet to be made 7.5 feet in diameter.

19. All of the pipe conduits to be provided with a proper number of outlet gates and air valves.

20. The right-of-way to be fenced where necessary; all repairs to be made to roads and streets through or across which the conduits pass.

21. Electric transmission pole line and wires for 13,000 H. P. from generating stations 110 and 120 miles from Newcastle and Orange Power stations to outlet of submerged conduit in San Francisco. The whole to be constructed in conformity with the most perfect specifications that experience has made known to the Art.

22. All the usual essential appurtenances to the water supply works, special connecting chamber at inlet to the submerged conduit, etc.

23. Telephone line from the San Francisco receiving point to Euchre Bar with telephone in place at all fixed points of report of the operative line employees.

24. Receiving Reservoir at discharge end of submerged conduit in the Potrero—Capacity 25,000,000 gallons. Concrete bottom and sides.

25. City distribution pumping plant—High Pressure Rotary Pumps, Electric Motors, 100,000,000 gallon aggregate daily capacity. Reserve plant gasoline explosion engines installed to permit of direct connection with the pumps.

This pumping plant we propose would be made of units of identical capacity and for a uniform range of lift. While as a fact the water has to be elevated to several levels between 200 feet and 550 feet, the plant would be so installed that the pump lifts would be between 200 and 300 feet. The power units, electric motors and explosion engines would also be equal. The parts for all of the units would thus be standard and interchangeable. The floor space required for the electric motors and pumps of the plant proposed would be 50 feet by 80 feet, 4000 square feet. For pumping 35,000,000 gallons daily, 8 hours' time of all the pumps would be required, employing four men.

26. City distribution system, street pipes and service reservoirs—The length of street pipes 400 miles, aggregate water-holding capacity 30 per cent. greater than the present Spring Valley Distribution Pipe System. Service reservoirs aggregate 100,000,000 gallons capacity. The suggested 200,000,000-gallon service reservoir is not included.

27. Vanden Pumping Plant—High Pressure Rotary Pumps, Electric Motors, 50,000,000-gallon daily capacity to 120 feet lift. Reserve plant gasoline explosion engines as a substitute for the electric motors.

The preceding specifications are necessarily only a general outline. It is assumed that all the unstated essential details are included in the construction we propose and that they are what the highest skill and most satisfactory experience to date would require.

PRELIMINARY PROPOSAL FOR CONTRACT FOR CONSTRUCTION.

On the preceding general specifications and enumeration of items of plant construction, with such details as your own Engineers would specify, provided they did not change the essential character or extent of plant construction as enumerated, we would be prepared to contract to build and deliver the complete system of works within two and one-half years from the date of the contract at a price which will not exceed $17,350,000, which contract sum shall include the conveyance of

1. The water rights of the undersigned and the water rights of the Giant Gap Water Company;
2. The franchise granted by Placer County to the use of the public highways for rights of way;

3. The right to the construction and use of the submerged conduit for the transport of the water and electric power only.

4. The rights of way for the canal line, heretofore acquired by the Giant Gap Water Co.

The fee title by grant deed to real estate as follows:

5. 4,000 acres, more or less, of watershed lands inclusive of mountain storage reservoir sites;

6. A strip of land inclusive of the situs of the canal through private lands not covered by the rights of way of the Giant Gap Water Company;

7. The situs and entire watershed area, 300 acres more or less, of the Elfland Reservoir at Bowman;

8. The situs, 10 acres more or less, for the Newcastle Power Station;

9. The situs and entire watershed area, 300 acres more or less, of the Orange Reservoir near Roseville (This includes the situs of the Orange Power Station);

10. A strip of land of sufficient width through private lands the situs of the four lines of the Upper Pipe Line between the Elfland Reservoir and the Orange Reservoir;

11. A situs for the Vanden Pumping Plant, 10 acres more or less, near Vanden, Solano County;

12. A strip of land of sufficient width through private lands crossed (or right of way to the use of such a strip) for the Lower Pipe Line from the Orange Reservoir to the receiving reservoir in San Francisco;

It is understood that the City's right of eminent domain would be available for all condemnation proceedings necessary and that the City should secure from the several Counties, the State and the United States the necessary grants or permits for crossing State lands, public or grant lands and navigable waters. It is also understood that the City would designate and provide the situs for the receiving service distribution reservoirs.

OFFER OF RIGHTS AND PROPERTIES TO THE CITY.

We appreciate the fact that the offer to contract construction that we make here is tentative, and cannot be formally considered at this stage in your order of procedure in this matter. We are presenting it primarily therefore so that you shall at this time have for comparison a concrete inclusive figure of estimated cost. Should you determine on the acceptability of the source of water supply we offer, and adopt generally the plan of works we suggest, we would then be prepared to make a formal offer of contract, inclusive of the entire system of works as the details would then be specified by your engineers.

On the other hand, should you conclude, that accepting the source of water supply from us, you desire that the City should have for itself the economy of cost incident to the subdivision of the construction of the works into sections that would be then contracted for in competition by specialists, we are willing to sell and convey to the City for the sum of $2,000,000 the following enumerated rights, franchises, easements and real estate in fee as follows:

1. The water rights as described above;

2. The franchise granted by Placer County as described above;

3. The right to the construction and use of the submerged conduit for the transport of the water and electric power only;

4. The rights of way for the canal line heretofore acquired by the Giant Gap Water Co.;

5. The field note books of survey of the canal line and the construction map of the ten mile section of the canal extending from the headworks at Euchre Bar through Giant Gap Cañon;

6. The construction of the canal line made by the Giant Gap Water Co. This includes one tunnel complete, 70 feet long, 60 feet of a second tunnel in Giant Gap Cañon, and between 45 and 50 miles of partial grade excavation of a total of 51¼ miles of the canal line. This is generally a trail on the survey grade line for the cutting. Together with the survey bench marks every half mile it makes the survey of easy and cheap restoration;

7. 4,000 acres, more or less, of lands in the watershed area. They include situs and floodable areas of storage reservoir sites;

8. 300 acres, more or less, of the land inclusive of the situs, floodable and entire drainage area of the Elfland Reservoir site;

9. 10 acres, more or less, a site for the Newcastle Power Plant;

10. 30 acres, more or less, a portion of the situs, floodable area and watershed of the Orange Reservoir site;

11. Certain contracts for the fee to private lands required for the situs of the pipe lines between the Elfland and Orange Reservoirs. The coutracts provide for a determination of the situs by survey and payment for the land at any time within a year;

12. 10 acres, more or less, a site for the Vanden Pumping Plant in Solano County;

Additional to the preceding enumerated we offer at actual cost to us.

13. Tracts of watershed land and land for pipe situs acquired by us subsequent to this offer and before it is finally acted on.

The City can with these properties and the economical advautage of directly dividing the necessary construction of the works into sections, and using detailed plans of our preparation, make the entire construction at a total cost not exceeding $14,000,000.

The City can at its election, in addition to the real estate we can convey to it, acquire by condemnation or by direct purchase such additional areas of watershed as it may from time to time desire. The land is low priced, and, except at a few points for mining, of little or no value to private owners. There is no reason why in time, and at a trifle of cost, the City should not become the owner in fee of the entire watershed.

For your assistance iu considering the source of water supply we propose and the system of works we suggest we give you (subject to return if our proposition is not accepted):

1. The Map and Field Books above described;
2. Certified copy of Notice of Location of the water right we offer you;
3. Abstract Records of Placer County showing all claims of water rights located on the North Fork of the American River and of its tributaries above Euchre Bar;
4. Legal Opinion of Tuttle, Chamberlain and Pullen & Wallace on the water right claims aforesaid;
5. Affidavits declaratory of physical status of water rights, etc.;
6. Certified copies of contracts and options on real property offered;
7. Legal opinion of Attorneys as to the title of these several properties;
8. Abstracts of title to the properties. (These last are unavoidably incomplete but will be added to as rapidly as prepared);
9. Copy of specifications, drawings, and claims of application for patent to the submerged conduit.

IN CONCLUSION:

We appreciate the fact that the water supply proposition we are presenting to you exhibits potentialities that you could not have anticipated, and demonstrates existing conditions as they could not have been imagined. We have endeavored in presenting it to do it logically and simply, so that, stripping it of details, the non-technical water consumer who reads it can understand it without the assistance of an expert. We have intended our explanations and figures to be such, and to be in such sequence, that one should not anticipate the conclusion from another subsequent, but that each simple element in turn apprehended, should become the foundation on which the next simple element is built.

There is nothing abstruse or puzzling in the figures of the Spring Valley works. Any accountant, or even a High School boy, can take pages 23 to 36 of Water Rates, Municipal Reports 1898–99, and given the mean daily consumption of water by the City, can calculate out the results stated in Table VI and other data used here.

Take for example from the Table on page 23 (Municipal Report 1898–99, Water Rates) for the year 1898–99:

	$ 458,750.80	Operating Expenses,
	100,000.00	(Est.) Taxes outside City and County,
	538,629.05	Interest,
	766,500.00	Dividends,
365)	1,863,879.85	Total Cost Charges.
24,000)	5,106.00	Cost Charges per day.
	.213	" " " 1000 gallons
	.748	(748 Gals.=100 cu. ft.)
	$ .16	Cost Charges per 100 cubic feet

Referring to page 44, same report (Under Meter Rates) Note for rates fixed under cost.

12th Sub. Between 40,000 and 50,000 cubic feet, 16 cents per 100 cubic feet.

13th Sub. Between 50,000 and 60,000 cubic feet, 15 cents per 100 cubic feet.

14th Sub. Between 60,000 and 70,000 cubic feet, 14 cents per 100 cubic feet.

15th Sub. All water in excess of 70,000 cubic feet, 13 cents per 100 cubic feet.

Our own estimates of operative costs have been prepared with the utmost care and to extreme detail, direct comparisons to check have been made with actual operative results obtained in many cities. The selection of Buffalo as a standard puts our proposed system to the severest possible test of comparison with actual results.

This comparison it should be borne in mind, however, is made between the two systems of plant as water supply propositions alone, but admit the water power of our proposed system as an integral part of it, and credit its net earning against the cost charges of the water supplied, and Buffalo becomes a far distant second to what San Francisco can be.

FINAL COMPARISON

What the City of San Francisco has in the Spring Valley Water Works (The official estimate of value made by the Company's Engineer for the Board of Supervisors Jan. 25, 1901.)	with	**What the City of San Francisco can have in the Proposed Giant Gap Water Works** Estimate of probable cost by the undersigned prepared for the presentation of the proposition herein made.
Sources of Supply — Populated and cultivated watersheds at low elevation, having light rain precipitation, and excessive heat in summer.		Source of Supply—Uninhabited, uncultivatable, watershed of high altitude, heavy rain precipitation and temperate summer heat.
Estimate of value of water rights, riparian rights, 27,500 acres of watershed and reservoir site areas, Calaveras water rights and franchise $27,785,000.		Price at which we offer to sell to the City water rights and 4,000 acres of watershed and reservoir storage areas, $2,000,000.
Estimate of value of storage reservoir dams (including Calaveras projected) $6,962,000.		Storage reservoir dams will cost not more than $900,000.
Estimate of value of supply service pipe lines, flumes, rights of way and appurtenances (including the Calaveras system projected) $12,928,000.		Supply canal, line reservoirs, pipe lines, submerged conduit and all appurtenances will cost not more than $6,900,000.
Estimate of value of pumping plants, exclusive of real estate, $1,192,000.		Pumping plants of twice the capacity of Spring Valley (inclusive of real estate) not more than $600,000.
Estimate of value of City reservoir sites, the reservoirs, City pipe distributing system, etc., $6,497,000.		The City parks furnishing some of the sites; the others necessary, the service reservoirs, and pipe distribution a third more than Spring Valley will cost not more than $4,000,000.

FINAL COMPARISON—CONTINUED.

Estimate of value of other properties, including Office building and Lake Merced drainage system,

$1,024,500.

Estimate of value total,

$56,388,500.

Net annual outgo cost charges paid by the City and consumers (for 30,000,000 gallons daily supply),

$2,607,000.

The Dearest Water in the World, and Getting Dearer.

Water power generating and electric transmission plant delivering 13,000 H. P. in San Francisco, will cost not more than

$3,000,000.

Estimate of cost,

$17,400,000.

Outgo: annual cost charges of water supply and distribution - - -	$ 894,615
And annual cost charges 6,000 Kw. electrical power - - - - - - -	108,000
	$1,002,615
Less—	
Income from sale of 6,000 Kw. electrical power in bulk to existing electrical companies at $.02 per Kw. hour which is less than the cost of production by them from fuel - -	$1,059,200

Net annual outgo for water

0,000,000.

The Cheapest Water in the World.

Respectfully submitted,

Russell L. Dunn

Wm C. Alberger

SAN FRANCISCO, CAL.

315 California Street, Room 15.